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Can You See It? Facial Expression Leakage in Response to Emotional Intensity

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Abstract

Do we see every facial expression from people with whom we come into contact? By replicating an experiment by Porter, ten Brinke, and Wallace (2011), this scaled-down study examined if high-intensity images elicit incorrect emotional "leakage" in participants' facial expressions. The idea facial expressions may not be fully consciously controlled emerged from Darwin's (1872) "inhibition hypothesis." Some facial expressions are too intense to voluntarily control, and thus cannot be fully controlled at all times. In the present study, 21 participants were asked to perform facial expressions (reflecting happiness, sadness, and fear) while viewing a series of images that varied in emotional valence. Some of the images were congruent with the expression the participant was instructed to maintain, while others were incongruent. Video recordings of each participant's facial expressions were then examined to see if any facial expression "leakage" occurred while they attempted to mask emotions during the study (189 total expressions and 28,350 individual slides). Statistically significant results supported the hypotheses and past research: facial expression leakage occurs more when viewing incongruent images with masked expressions than when viewing congruent images with genuine expressions.

Can You See It? Facial Expression Leakage in Response to Emotional Intensity

The human face is an abundant canvas of information. It is humans' most complex source of non-verbal communication; however, it is often taken for granted. As people develop, they become experts at the perception and recognition of expressions. Interpreting facial expressions has incredibly widespread benefits in social interactions. Detecting others' interests, emotions, and states of mind are all important benefits of facial expression recognition. This study aimed to determine if masked expressions would lead to greater levels of emotional leakage compared to genuine expressions.

Literature Review

Face Basics

The human face has evolved into a very complex system of muscles, bones, skin, and tissues. Throughout many animal species, there appears to be a unified blueprint for facial structure (Bruce & Young, 2012). The bottom of the face features a central mouth, above which is a nose with two nostrils, and, at the top, two horizontally placed eyes. Nearly all animal faces have external bilateral symmetry (Bruce & Young, 2012). However, there is one primary difference between human faces and most other mammal faces: they are primarily hairless with the exceptions being the eyebrows and hair on the scalp (excluding facial hair) (Bruce & Young, 2012). This difference greatly helps the recognition of human facial expressions. The eyebrows in particular serve as a key communicator in facial expressions (Ekman, 1979). The absence of expression-blocking features on the human face aids in understanding what others are feeling, and they can help to explain why humans have evolved to be so adept at reading expressions from the eyebrows, lips, and eyes.

Facial Muscles

Humans can physically make facial expressions through a number of important muscles. One of the first scientists to discover how muscles impact facial expressions was French physician Duchenne de Boulogne in 1862. While electrically stimulating the face muscles involved when a subject smiles, he found the resulting smile to appear disingenuous (Duchenne, 1990). Later, in 1990, scientists discovered real, genuine happiness also involves an involuntary contraction of the *orbicularis oculi* muscles surrounding the eyes (Ekman, Davidson & Friesen, 1990). Smiles denoting genuine happiness must include not only the upturn of a person's lips, but also the wrinkles around the outside of his or her eyes.

Paul Ekman developed the Facial Action Coding System (FACS) for denoting which specific muscles are used when a person elicits a certain emotional facial response (Ekman & Friesen, 1976). The individual, fundamental components of facial expressions are known as Action Units (AUs), and are made up of the movement from one or more muscles. Each of the seven universal emotional expressions humans make, which are discussed further below, are made up of several AUs. Whereas other techniques measure muscle movement through electrical signals, this anatomical approach can classify all expressions humans make solely through visible muscle movement. Ekman's system for classifying expressions by sequences of muscles has greatly increased scientific knowledge of facial expressions.

Facial expressions follow along two neural-muscular tracts. Voluntary facial actions emerge in the cortical motor strip, which is driven by the pyramidal tract. Involuntary expressions emerge in the subcortical areas of the brain, which are driven by the extrapyramidal tract (Matsumoto & Hwang, 2013). It is interesting to note that humans share these subcortical regions with other primate relatives, which may suggest certain uncontrollable and fast-tracked emotions are instinctive and evolutionary.

Human Perception of Faces

Although this thesis does not focus specifically on how humans perceive faces, it is important to set a foundation. An increase in technology over the recent decades has greatly aided scientists studying the neural structures involved in face perception. An informative study by Kanwisher et al. (1997) used functional magnetic resonance imaging (fMRI) to study specific regions of the brain. The fusiform face area (FFA), located in the fusiform gyrus, is tuned selectively to the perception of faces. Although there are other regions in the brain for perceiving objects, primarily the lateral occipital complex (LOC) (Grill-Spector & Sayres, 2008), face detection and perception occur specifically in the facial fusiform area.

Further research revealed the sensitivity of the FFA to differences in relationships of facial features (Rhodes et al., 2009). By implementing a functional magnetic image resonance (fMRI) design, the scientists found participants' FFAs responded more strongly to repeated faces with small changes in facial features than to repeated identical faces. The finding advanced the idea that humans are very adept at noticing small changes in faces, which plays an important role in the recognition of minute differences in the expressions of other faces. Recognition of minute changes is important for every type of social interaction.

Another influential study on how humans perceive faces was conducted by Haxby et al. (2000), who argued that "the face perception system must represent both the invariant aspects of a face that specify identity, as well as the changeable aspect of a face that facilitate social communication" (p. 223). Those authors concluded there was a core system for human visual analysis. The superior temporal sulcus (STS) appeared to function as an area for the changeable features of faces, which includes expressions and eye and lip movements. While the FFA responds more selectively to faces, the STS responds with greater intensity to facial expressions and brief changes in facial appearance.

Humans process information and details from faces more accurately and faster than other types of objects (Hershler & Hochstein, 2005), which further supports the idea that humans' facial perception and expression recognition systems evolved to become more adept in social situations. For early humans, the social benefits of facial perception were, and still are to this day, of extreme importance. Accurately judging threatening intentions, welcoming smiles, and hesitating suspicions helped people approach safe situations and avoid dangerous situations depending on the flash judgments of others' states of mind.

Some individuals, however, are unable to recognize faces, which has been given the term prosopagnosia (Meadows, 1974). There is evidence to support that people with prosopagnosia, and other forms of face blindness, are able to effortlessly identify other animals and objects but struggle with recognizing familiar human faces (McNeil & Warrington, 1993). Typically, individuals with prosopagnosia developed the condition from sustaining a brain injury; however, some individuals are born with or develop prosopagnosia over their lifetimes (Bate & Tree, 2016). These findings support the idea that there are separate regions of the brain dedicated to processing and recognizing faces and objects. Damage sustained by one system (facial perception) does not extinguish recognition of the other (object perception).

Human Facial Expressions

While face perception and recognition are detailed and interesting topics, the focus of this particular study is facial expressions. The face is one of the most sophisticated nonverbal means of communication for humans. Facial emotions provide insights into people's states of mind, feelings, and intentions. Facial expressions develop from emotions that are "immediate, automatic, involuntary, and unconscious reactions to events" (Matsumoto & Hwang, 2013, p. 15). Furthermore, there is much evidence to support the universality of human facial expressions of emotion.

Paul Ekman and Carroll Izard performed what came to be known as the "universality studies" in 1971 and 1972. They discovered six universal facial expressions - anger, disgust, fear, sadness, surprise, and happiness (and later, a seventh, contempt) - existed in cultures and communities around the world (see Figure 1). The experiments took into account the idea that facial expressions were learned through mass media or the enlargement of Western culture, by using participants from two preliterate tribes in remote areas of New Guinea. These tribes had never had contact with the globalized society, which helped to support the belief that expressions appeared to be biologically prepared. Resent research, however, has refined Ekman's research by demonstrating that not every society can distinguish Western facial expressions (Gendron, Roberson, van der Vyver & Barrett, 2014).

Further evidence to support the biological innateness of human facial expressions involved studies examining congenitally blind athletes. Matsumoto and Willingham (2009) studied the expressions of non-congenitally and congenitally blind judo athletes during the 2004 Athens Paralympic Games. They compared those athletes' expressions with sighted judo athletes in the 2004 Athens Olympic Games. The expressions of the blind athletes were situationally appropriate and functioned very similarly to the sighted athletes' expressions (Matsumoto &

Willingham, 2009). This result helped to demonstrate expressions appear to be, to a certain extent, reflexive and innate rather than learned.

There are three ways an emotion may be intentionally altered through facial expressions: simulated, masked, and neutralized (Ekman & Friesen, 1975). Simulated expressions occur when the expression is not paired with the real emotion. For example, this happens when someone smiles at an image that he does not feel genuine happiness toward. Masked expressions, on the other hand, occur when a false expression replaces the correct expression. For example, this happens when a person tries to smile at an image that elicits disgust. Neutralized expressions occur when a genuine expression is blocked. For example, this happens when someone limits his excitement to appear impartial.

Micro and Subtle Expressions

Charles Darwin's inhibition hypothesis, whereby some emotions are too intense to be consciously controlled and will be displayed through a person's facial expressions, can be further examined with the concept of microexpressions. Microexpressions were first discovered by researchers studying psychotherapy session films (Haggard & Isaacs, 1966). These expressions last less than 0.5*s* and are often believed to be emotions a person desires to conceal. This idea coincides with the function of the extrapyramidal neural tract, which evokes uncontrolled, automatic emotional expressions. Microexpressions are often so quick that people do not report showing any expression, yet slowed film demonstrates otherwise. For example, contempt is a subtle expression that many may not be consciously aware they show in certain situations.

The present study, however, focused more closely on subtle expressions. These are low-intensity facial expressions that occur at the onset of someone feeling a certain emotion

(Matsumoto & Hwang, 2013). Typically, they are produced with the same muscles of the full expression but at a lower intensity. Subtle expressions may also only be seen in either the top half or bottom half of the face. These partial expressions are low-intensity forms of full expressions. People who are better able to perceive partial and subtle expressions in faces are more likely to detect deception (Warren et al., 2009). This finding was important for the present study, because people who are more sensitive to facial expressions may display less leakage as they are more attuned to noticing detailed facial expression information in others, and they may be more aware of their own expressions.

The Present Study

There are important social implications for recognizing brief displays of emotional leakage in other people. Emotional leakage refers to facial expressions that incorrectly spill from people's faces. The central question this study examined was whether facial expression leakage occurred more when viewing conflicting images for a certain facial expression. More specifically, it tested how participants displayed facial expressions toward images that elicited congruent (genuine) emotions, incongruent (masked) emotions, and neutral images that elicited neutral emotions.

Using Darwin's (1872) inhibition hypothesis as a backdrop, the study was designed to test if participants had fully conscious control over their emotional expressions. By replicating Porter, ten Brinke, and Wallace's (2011) study, which was the "first to directly test the proposition that intensity has an impact on the presence and duration of emotional leakage during simulated, masked, and neutralized expressions" (p. 26), this study further examined the idea that people have conscious control of expressions regardless of social situation. The present design scaled down the previous study. Three emotions were studied (instead of happiness, sadness, fear, disgust, and neutral in the previous report): happiness, sadness, and fear. These three emotions, and their connected facial expressions, were selected because of their diversity. The three emotions are common in day-to-day life, and they were believed to be easily perceptible for participants to produce. Sadness is the opposite of happiness, whereas fear is a powerful flight-or-flight emotion often activated by the sympathetic nervous system. There were three hypotheses for this study: 1) masked, incongruent expressions would show greater amounts of expression leakage compared to genuine, congruent expressions; 2) both neutral images and congruent images would elicit minimal facial expression leakage; and 3) all participants would display some form of facial expression leakage.

Method

Participants

Participants (10 women, 11 men, M_{age} = 19.14 years) were all students at a medium-sized liberal arts college in the Mid-Atlantic. Participants endorsed the following identities: 76.2% reported being white, 9.5% reported being Asian, and 14.3% reported being black. Participants were recruited from the introductory psychology courses offered on campus. In return for their participation, participants were given credit towards a class assignment. Participants signed up for a 30-minute time slot through an online subject pool management system (Sona Systems). All participants were notified that they would be visually recorded while viewing images and that all information would be kept confidential.

Materials

Participants viewed images compiled from the International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 2008). Nine images were used in the study. They were split into three types: happiness, sadness, and fear. The file name numbers for the fear images used in two trials were: 1525 and 6230 (a vicious dog and a loaded gun, respectively). The file name number for the sadness image was 2703 (crying children). The file name numbers for the neutral images were 5731, 7175, and 7490 (a door, a lamp, and a window, respectively). The file name numbers for the happy images were 1463, 1710, and 2071 (happy kittens, a smiling infant, and happy puppies, respectively). Each phase of this study had three trials: the first trial (happiness) presented a happy image, a fear image, and a neutral image. The second trial (fear) presented a fear image, a happy image, and a neutral image. The third trial (sadness) presented a sad image, a happy image, and a neutral image.

The images were presented to participants using Microsoft PowerPoint. Participants were recorded with a Canon Vixia camcorder in 720p at 60fps. The researcher was trained in expression recognition software created by Humintell.

Procedure

Three individual PowerPoint slideshows were presented to participants. All featured the same images in three randomized orders. The three expressions participants were asked to demonstrate were happiness, sadness, and fear. The three images shown for each expression were kept the same - only the order of the images and the expressions were changed. The present study focused solely on the amount of expression leakage from genuine, neutral and masked image expressions. This study focused solely on three expressions to reduce the likelihood of Type II errors made from multiple comparisons.

Participants were recorded in a private study room in an on-campus facility. The same room was used for all participants. At the start of the study, participants reported their demographics, such as their age, race, and gender. After the demographic questions, they were provided instructions for the study. PowerPoints were presented on a 2012 non-retina 13” MacBook Pro laptop (resolution: 1280 by 800 pixels) with the brightness on the highest setting. The camcorder was set up using a tripod and was positioned to show as clear an image of the participant’s face as possible. The room’s lighting was kept consistent throughout the study. The slideshows included an informational task screen before each set of three images was shown. The instructions provided the participant with the specific expression to show. Participants were given notice that a 440Hz tone (approximately 70.3 dB) would play only when the images were shown, which provided the researcher with information during the recording of when to code the expressions.

The participant was instructed when to press a key to advance the task. The images and neutral slides were on a preset timer. A two second slide instructed participants to show the instructed expression. Then there was a five second slide of an image. The tone matched this slide. The final slide in the series was a break slide, which instructed participants to neutralize their facial expression and bring it back to a resting state (see Figure 2). During the break slide, participants were able to advance to the next task at their own pace. After the study was completed, participants were debriefed and permitted to ask any questions about the study that they may have had.

Leakage scores were calculated by counting the number of individual slides over the 5*s* that displayed expression leakage. Of the 150 frames per expression, slides were examined at 30 frames per second (fps). Each 30 frames equaled 1*s*. The researcher was blind to the veracity of the expression while coding to reduce any biases toward confirming the study’s hypothesis with knowledge of the trial being coded. For example, if a participant leaked a fear expression during a trial for happiness for 25 of the 150 frames, their leakage score would be 25.

Results

Paired samples *t*-tests and repeated measures ANOVAs were used to test the main hypotheses (see Figure 3). Statistical tests were run on all trials, but only statistically significant results are reviewed below. A paired samples *t*-test was conducted to compare facial expression leakage between the masked happiness-inducing image and the neutral happiness-inducing image. There was a significant difference in the leakage scores between the masked image (M = 22.38, SD = 31.43) and the neutral image expression (M = 5.10, SD = 8.24) conditions, $t(20)$ = 2.52, $p < .05$.

A second paired samples *t*-test was conducted to compare facial expression leakage between the masked happiness-inducing image and the genuine happiness-inducing image. There was a significant difference in the leakage scores between the masked image (M = 22.38, SD = 31.43) and the genuine image expression (M = 4.76, SD = 9.61) conditions, $t(20)$ = 2.36, $p < .05$.

A third paired samples *t*-test was conducted to compare facial expression leakage between the masked fear-inducing image and the genuine fear-inducing image. The difference in the leakage scores between the masked image (M = 44.71, SD = 51.21) and the genuine image expression (M = 21.62, SD = 21.10) conditions was in the expected direction but did not reach conventional levels of statistical significance, $t(20)$ = 1.90, $p < .10$.

A fourth paired samples *t*-test was conducted to compare facial expression leakage between the masked fear-inducing image and the neutral fear-inducing image. There was a significant difference in the leakage scores between the masked image (M = 44.71, SD = 51.21) and the neutral image expression (M = 18.19, SD = 34.09) conditions, $t(20)$ = 2.78, $p < .05$.

Statistically significant results from a repeated measures ANOVA with a Greenhouse-Geisser correction, which is a conservative correction for the degrees of freedom to limit the negative effects of sphericity (Abdi, 2010), demonstrated facial expression leakage occurred more during the masked, incongruent image for happiness than in the genuine, congruent image, $F(1.214, 24.277) = 5.516$, $p = .022$. The same was true for the comparison between the masked, incongruent image for fear than in the genuine, congruent image, $F(1.704, 34.076) = 3.986$, $p = .034$.

There were no statistically significant results from a repeated measures ANOVA with a Greenhouse-Geisser correction during the sadness trial, $F(1.83, 36.65) = 0.79$, $p = .45$.

When filtering the dataset to include only male participants, there were no statistically significant effects for the happiness, fear, or sadness trials. However, when filtering the dataset to include only female participants, statistically significant effects reappeared. A repeated measures ANOVA with a Greenhouse-Geisser correction demonstrated facial expression leakage occurred more for females during the masked, incongruent image for happiness than in the genuine, congruent image, $F(1.606, 14.454) = 4.812$, $p = .031$. There were no significant results from a repeated measures ANOVA during the females' fear and sadness trials.

Discussion

These results generally supported Porter, ten Brinke, and Wallace's (2011) findings. Facial expression leakage occurred more frequently in masked, incongruent expressions than in genuine, congruent expressions. However, the results for the sadness trial did not reach significance, which will be discussed further below. Results from the happiness and fear trials supported previous research in the field of facial expression leakage. Daily human experience necessitates interactions with others. People's ability to produce facial expressions enables nonverbal communication and emotional understanding, and it is a significant aspect of daily life. Facial perception is critical to our interpretation of face-to-face interactions.

Happiness and fear expressions displayed the greatest amount of leakage. Expression leakage in response to both neutral and congruent images was less likely than it was for incongruent images. When participants were asked to provide an expression that was congruent with the image presented, their levels of leakage were much lower than for images that did not match the expression. Neutral images did not feature higher levels of expression leakage, which suggests that participants were reacting more to incongruent images solely because they did not induce the appropriate emotional expression. Participants viewing neutral images did not show the same degree of leakage as during the incongruent expression because the emotions evoked were not strong enough to elicit leakage. Although the neutral images were not "congruent" per se with the tasked expression, the emotional intensity was not present when compared to the higher intensity incongruent images.

Total conscious control of expressions was not possible, which supports Darwin's inhibition hypothesis (Darwin, 1872). Every participant demonstrated some form of expression leakage at least once. Interestingly, the most intense deception occurred over 5-10 individual slides, which equates to roughly 150-350 milliseconds. Expressions leaked incredibly quickly when participants were asked to view an image that did not equate with the emotion they were supposed to display.

One possible reason why the sadness trial did not reach statistical significance was that the images were more emotionally intense than the other two trials. Expression leakage occurred in both the congruent and incongruent images, which suggests that the congruent image may have elicited even stronger congruent feelings than the participants were prepared to show. This is further supported by the fact that this image was the only image to display people. This may be an avenue for future research: do people respond with more facial expression leakage to images of objects and other animals or to other humans? Regardless, although these results did largely support previous research in the field of facial expressions, there are numerous improvements to be made in order to increase our understanding of the findings.

Limitations and Future Directions

While this study generally supported past research in the field of facial expression leakage, there are a few details that warrant consideration. This study's statistical power suffered from its low number of participants. Each participant viewed nine images for five seconds each. When analyzing the data, each second of the image was viewed at 30 fps. For all 21 participants, and the resulting 189 expressions, the researcher viewed 28,350 individual slides. Without a research team to provide assistance, this was deemed a plausible number of participants to run with the amount of data that would be collected and then coded. A greater number of both images and participants would improve on the study's statistical power.

Another limitation of this study was there was only one expression leakage coder. Past research has been conducted using multiple independent coders to accomplish as reliable a score as possible. The researcher in the present study implemented numerous measures to ensure the coding was reliable including being blind to the trial to limit the likelihood scores were coded to support the study's hypotheses and coding random images twice to check for coding accuracy.

There are a number of avenues to be addressed in future studies. This study focused solely on college-aged students. It would be of interest to the field to study how facial expression leakage changes in different age groups. Another avenue for future research would be to include a self-report condition after participants viewed the images, which would provide feedback on whether or not people are aware they display facial expression leakage or not. Past research has had untrained observers view participants in the process of completing the study and found that the untrained observers were not able to identify facial expression leakage (Porter, ten Brinke & Wallace, 2011). This aspect of past research deserves further focus. Overall, facial expressions are an integral part of daily life interactions. We glean considerable information from other people's expressions. The avenues mentioned above merit attention from researchers in the field of facial and expression recognition.

In summary, in agreement with past research, incongruent expression leakage occurred more frequently during fear and happiness expressions. Finding statistically significant results with a smaller amount of data compared to other similar studies reinforces the central relationship in this study: every person displays facial expression leakage – if you can see it.

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Figure 1

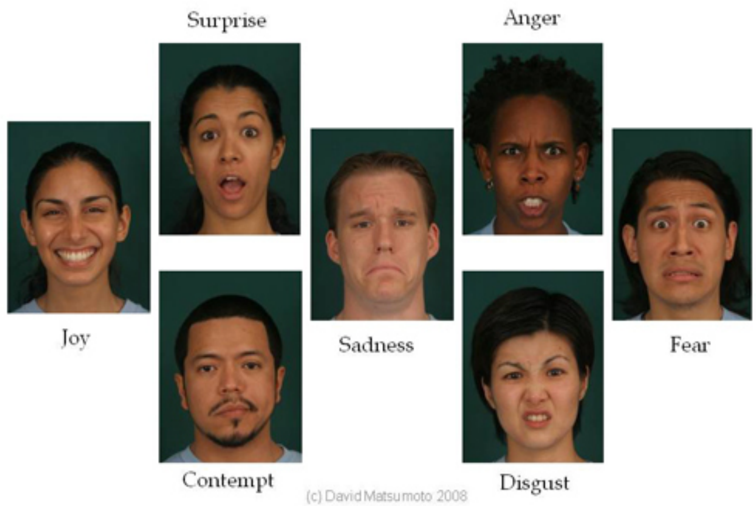
Surprise
Anger
Joy
Sadness
Fear
Contempt
(c) David Matsumoto 2008
Disgust

Figure 2

Presentation progression diagram

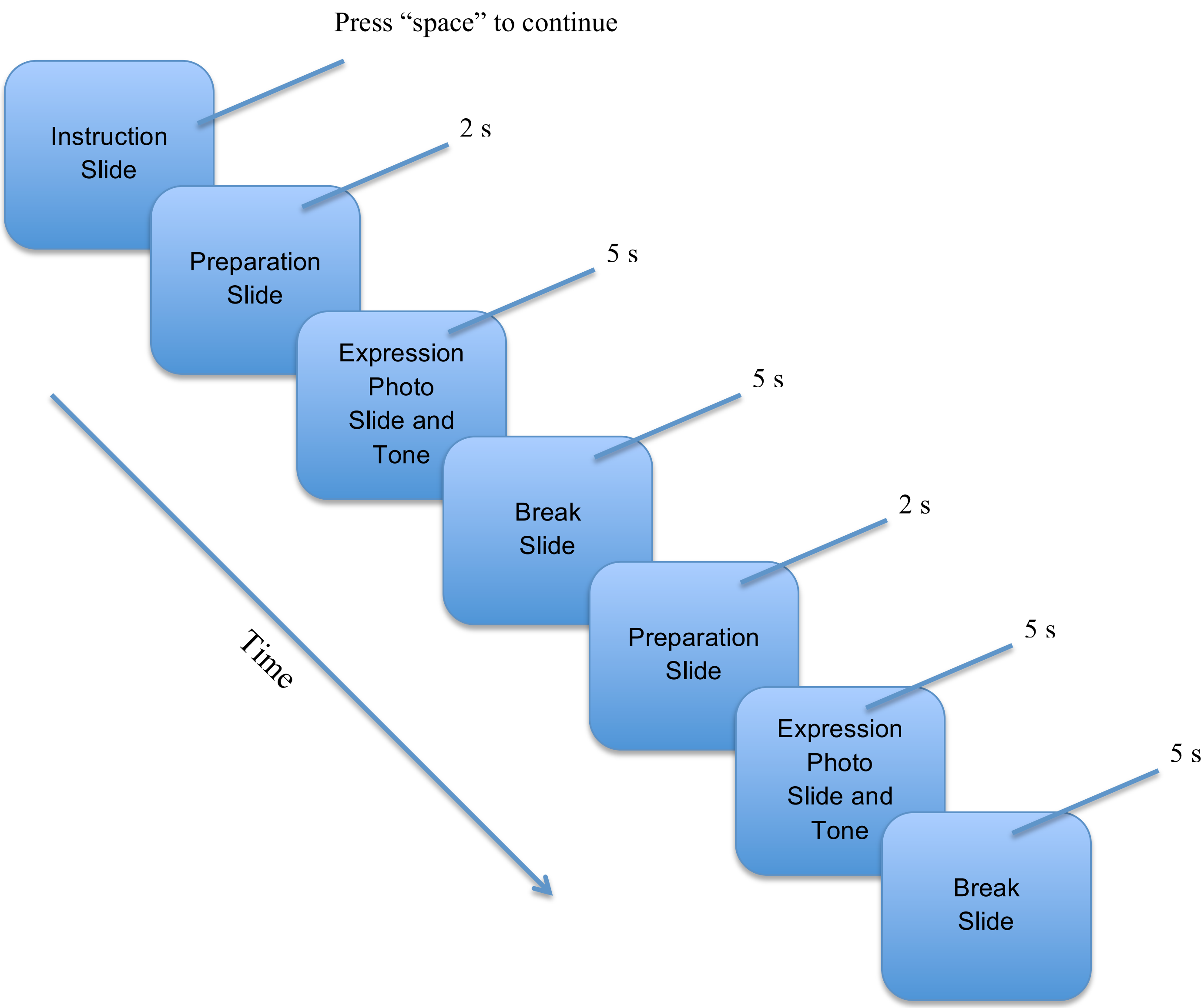

Figure 3

Graph: Average Leakage Scores