Emotional Faces and Cognition

The Effects of Ekman's Facial Action Task on Memory

A Senior Thesis submitted in partial completion of the major in Linguistics and Cognitive Science

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Ekman (Ekman, 1992) developed the Directed Facial Action Task (DFAT), which demonstrated that facial expressions can elicit emotional physiology. The present study investigated whether these responses also have mood-congruent memory effects, as found when emotions are elicited in other ways. 38 participants performed the DFAT for happy and sad expressions before recalling neutral, positive and negative images. The mood-congruent memory hypothesis predicts that, if the DFAT produces sustained affect, participants should recall more mood-congruent than mood-incongruent images. Some participants performed the DFAT while Galvanic Skin Response, an index of autonomic emotional response, was recorded. GSR correlated with reported mood change in the happy condition, while the difference between mood-congruent and –incongruent memory correlated with reported mood change in the sad condition. However, there was no correlation between GSR and memory. These results show that self-reported emotion but not physiological response was linked to congruency effects in memory for emotional images.

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Over a century ago, William James proposed an idea which has remained strong in psychology ever since. He hypothesized that the physiological reaction of an emotion – sweating palms, a racing heart, a gnawing sense of unease in the pit of the stomach – precedes and causes its conscious experience. He illustrates this theory with an example: if a person came upon a bear in the woods, he would feel his heart begin to pound and the adrenaline start to rush as his fearful response took over. However, according to James this hapless person would feel fear only after registering these physiological changes, rather than the subjective feeling of fear generating the body's response (James, 1884). This is now known as the James-Lange theory.

In more recent years, Paul Ekman (Levenson, et al., 1990; Levenson, Carstensen and Ekman, 1991; Ekman, 1992) has built upon James' idea by focusing on one aspect of emotional physiology: facial expression. Ekman simultaneously builds off of Darwin's work on universal basic emotions and James' work on emotional physiology. He extends James' original hypothesis to argue that arranging one's face into an emotional expression is sufficient to prompt a conscious emotion. The following study will further investigate Ekman's claims regarding the relationship between emotions and facial expressions. Before examining this specific hypothesis, we will first describe the current theories of emotion and cognition which inform this investigation.

Theories of Emotion

Emotion can be defined in many ways. Although the current study does not directly examine the neurobiology of emotion, it is useful to frame its discussion with a background of how the brain's neural networks represent it. The neuroanatomy of emotion implies a distributed system which incorporates both the bottom-up, perception-based information of the evolutionarily older limbic system and the top-down, cognitive processes of the neocortex

(Dalgleish, 2004; Pessoa, 2008). While the striatal complex and the basal ganglia are generally understood to generate “primitive” emotions, such as fear, other structures govern more complex, social emotions and work to integrate them into ongoing cognitive and perceptual processing. These include the amygdala, hippocampus, thalamus, hypothalamus and cingulate cortex. Although most of these structures are subcortical, the behavioral interaction between cognition and emotion implies that neocortical areas in the prefrontal and ventromedial cortices are also heavily involved in emotion. Thus, emotional processes are not isolated in the brain. Rather, the brain’s neural connectivity allows them to interact extensively with cognitive and perceptual processes, a characteristic that will be motivate the current study.

Although there is little debate over the neural architecture supporting emotion, no such consensus exists on the causal relationship between physiology and emotion. There is little doubt that emotion is tied to physiological reactions. Most brain scientists follow Darwin in arguing that emotions serve an evolutionary purpose through their accompanying physiological responses (e.g. Öhman, et al., 2001). Automatic responses accompanying emotion, such as changes in heart rate and blood flow, as well as certain action tendencies such as approach or withdrawal, redirect attention and prepare the body for a survival response.

However, it is unclear whether these automatic responses trigger the conscious awareness of emotion. The James-Lange theory argues that they do, proposing that different patterns of physiological responses trigger different neural patterns which code for different emotions. Once a given emotion’s “code” has been activated in the brain, conscious experience follows. Nearly a century later, Ekman began researching emotional faces and assumed this same theory’s relationship between physiology and emotion. Some supporters of this theory add in a feedback loop between the body and the brain (Laird, 1974; Lanzetta, Cartwright-Smith & Eleck, 1976;

Reisenzein and Studtman, 2007), allowing a less linear causal relationship between emotion and physiology. However, Ekman (1992) argues that, even if the relationship is less linear in most natural circumstances, physiology is still powerful enough to motivate conscious emotion on its own.

Still others define emotion primarily in terms of "feeling," or the conscious, physical experience of affect. Richard Davidson (Davidson, 2003) castigates this last tendency as the seventh "sin in the study of emotion," citing evidence of very low correlations between self-reported affect and differential blood flow to emotional areas of the brain. Davidson takes this to imply that, "much of the affect that we generate is likely to be non-conscious," and points out that emotional processing involves "regulatory processes that…are likely not represented in conscious experience". Thus, emotional processing can be nonconscious and therefore have no accompanying physical sensation or "feeling". And this, according to Davidson, does nothing to negate the existence of an emotion. Whether a non-conscious emotion would be powerful enough to affect cognition remains an open question. In summary, the relationship between physiological changes and mental representations of emotion remains unclear and is an issue which this study intends to address.

Ekman and Basic Emotion

Ekman's 1992 paper lays out the theoretical basis of his experimental work. Under this theory, there are six basic emotions: happiness, sadness, disgust, anger, fear and surprise. Any other emotional states result from blends of the basic emotions. Other work (Levenson, et al., 1990) argues that these emotions are universal. In addition, each of the basic emotions corresponds to a universal facial expression, codified by Ekman and Friesen (1976) in terms of "action units" or muscular contractions. According to these studies, these emotional facial expressions are capable of instigating an emotional response without any additional stimulation from the environment. As we shall soon see, this is a version of the "sufficiency hypothesis."

Ekman's research investigates this model of the role of facial expression in the conscious experience of emotion. Using the Directed Facial Action Task (DFAT), a series of muscle-by-muscle instructions used to manipulate a neutral face into an emotional one, Levenson, et al. (1990) measured participants' autonomic activity (heart rate, skin conductance, finger temperature and somatic activity) at a baseline and while holding an emotional expression. Participants were tested for the six "basic emotions": anger, disgust, fear, happiness, sadness and surprise. The results indicated that facial expressions prompted significant changes in autonomic activity (which was taken to be evidence of an emotional response when confirmed by self-report), and that the patterns of autonomic activity was emotion-specific.

This last result was necessary to support Ekman's theory, for unless the physiological activity was emotion-specific it would be implausible to suggest that a person could correctly infer his or her emotional state based on physiological evidence alone. However, it requires qualification: while the authors claim to have found emotion-specific autonomic patterns, they mainly found a significant difference between positive (happy) and negative (the other five) emotions. Levenson, et al. (1990) also argues for the existence of significant differences in autonomic change among the negative emotions (based only upon heart rate and skin conductance); however, they failed to identify a specific pattern differentiating the physiological responses to these separate emotions, and instead found only a confused combination of trends to distinguish between negative emotions.

Levenson, Carstensen and Ekman (1991) extended these results in a study which compared use of the DFAT and traditional cognitive methods (the relived emotions task) to induce an emotional response in elderly participants (mean age = 77). Autonomic Nervous System (ANS) activity, including heart rate, finger temperature, somatic activity and skin conductance, were the dependent measures. The study revealed similar autonomic responses to those found in the 1990 study. In addition, it found significant differences in ANS activity between tasks, except for finger temperature. The authors used this result to argue that targeting physiological arousal through the DFAT was just as effective at prompting an emotional response as targeting cognitive mechanisms.

Ekman's model of the interaction between emotion and physiology explains that physiological activation causes emotion through one of two routes. According to the first route, the activation of the motor cortex in order to manipulate the face simultaneously activates the facial nucleus (a region of the brainstem that belongs to the facial nerve) and the ANS in parallel through a direct and innate connection. The second route is less direct: a "central pattern detector" scans the activity of the facial nucleus, and when it detects an emotional face it initiates an emotion-specific affect program which in turn activates the ANS. The neural correlates of the latter part of these routes (the activation of an emotion-specific ANS response) are relatively well-established –Ledoux describes a connection between the amygdala (which would likely act as a "central pattern detector" in combination with the thalamus) and the brainstem (cited in Ekman and Davidson, 1994, p. 220). Ekman and his colleagues never explain what mechanism causes the initial physiological change of the face in a naturalistic context – the above account is restricted to the controlled induction of an emotional face in the laboratory.

However, Ekman's claims hinge on the assumption that the co-existence of an autonomic response and self-report of affect (which could easily be influenced by demand characteristics and other conditions of the experiment, and thus may not accurately measure emotion (e.g., Davies & Best, 1996)) implies an emotional response. This may very well be true, but without further testing of cognitive effects such an assumption cannot be taken as fact. And in fact, Robert Levenson cites Ekman admitting that, "the presence of any one of these elements [physiological arousal, cognitive appraisal, coping behavior, etc.] is not sufficient to establish that an emotion has occurred" (Levenson, et al., 1990). And as Davidson (2003) pointed out, "feelings" comprise one component of the process of emotion (see above), and it is not clear that physiological arousal is necessary in order to experience an emotion (Dalgleish, 2004). Gerald Clore echoes these doubts, writing that "whatever feelings and physiological responses are produced directly by these noncognitive means may be just that – feelings and physiological responses. Even though these are constituents of emotion and may trigger or amplify emotions, they are not emotions themselves" (cited in Ekman and Davidson, 1994, p.183). According to Clore, a true emotion includes cognitive processing that accesses world knowledge, such as the fact that bears are dangerous animals.

Further, a question which lingers throughout the literature is whether experimental measurements of differential ANS activation can be taken to be truly emotion-specific. As Joseph Ledoux humbly points out,

> The important point to keep in mind is that the magnitude of the undifferentiated, nonspecific arousal responses should not be the gold-standard against which the other changes are measured. The resolution of our measuring instruments should not be mistaken for the resolving power of our minds and bodies. Differentiation, regardless of how small and difficult to measure, may be psychologically and/or physiologically significant. On the other hand, it may not be significant at all" (cited in Ekman and Davidson (eds.), 1994, p. 249).

Even Ekman's collaborator Robert Levenson shares some of Ledoux's skepticism, asserting that, "It seems far more likely that reliable autonomic differences will only be found between emotions for which the associated prototypical behaviors are quite different. And even among that smaller set of emotions so defined, it is quite unlikely that each of them will be automatically *unique,* sharing no features in common" (cited in Ekman and Davidson (eds.), 1994, p. 254). All of this uncertainty regarding Ekman's theory, as well as his experimental methodology, justifies a deeper examination of the mechanisms potentially involved in emotional processing.

Emotion and Cognition

Whereas behaviorist psychologists paid little attention to cognition and the human mind, the cognitive revolution championed the study of higher-order processes and their relation to other mechanisms in the brain. Emotion, as it turns out, is often intrinsically linked with cognition. Attention, learning, memory, behavioral inhibition and language have all been implicated as aspects of cognition affected by emotional state (e.g. Pessoa, 2008; Lapierre, et al., 1995, Harris & Pashler, 2005). For example, Mackay (Mackay, et al., 2004; Mackay & Ahmetzanov, 2005) has studied how emotion affects attention and memory using the Stroop task. The Stroop paradigm requires participants to name the color of text in which a word is presented. Various aspects of this task can be manipulated – the taboo Stroop task presents taboo words in colored text, thus adding an emotional processing demand to the task.

Mackay, et al. (2004) found three main effects resulting from the taboo Stroop paradigm: increased color-naming times for taboo versus neutral words, increased recall of taboo words and higher recognition of text color for taboo words. These results, and those presented in Mackay & Ahmetzanov (2005), lead to a hypothesis that emotional items activate the amygdala, which in turn communicates with the hippocampus that the emotional material has a preferential status in memory. As a result, emotional items will be "bound" to memory before neutral items, an obligatory process which precedes other processes such as naming colors, causing a longer reaction time.

The attentional functions of emotion fit in with the evolutionary arguments described above. Öhman, et al. (2001) found that fearful stimuli, such as pictures of snakes and spiders, captured perceptual resources preconsciously. Participants presented with a grid of fearful and non-fearful pictures managed to perform a visual search and correctly identify fearful items more quickly than neutral items, indicating a preconscious mechanism (likely mediated by the amygdala) capable of evaluating the environment's affective content and giving a processing advantage to emotionally salient items. This evidence suggests that no search was necessary to find the emotional targets.

Further, Eich, Macauley & Ryan (1994) and others have demonstrated another example of this interconnectivity between cognition and emotion in mood-congruent memory. This phenomenon occurs in the following pattern: mood-congruent and mood-incongruent material is learned while the participant experiences a mood. Bower (1981) suggested that the congruency between the mood and the material gives that material an attentional advantage at encoding, and thus the material is more deeply processed and linked into the associative network (Ruci, et. al, 2008). As a result, "people attend to and learn more about events that match their emotional state" (Bower, 1981) and the participant will later recall more mood-congruent than -incongruent information, regardless of their mood at recall.

Bower (1981) proposes an Associative Network theory of memory to explain this interrelation of emotion and memory. According to this theory, semantic memory is represented in the mind as a connectionist network, with nodes representing concepts such as emotion and events in memory. For example, the memory of a horror movie *(a)* is connected with an emotional "fear" node *(b)*. According to Bower, if one experiences a congruence between the affective content of the learned material and one's own emotional state at the time of encoding, this link between emotion *b* and event *a* will become stronger as activation continues to bounce back and forth between the two nodes, “as well as strengthen the associations within the event description itself” (Bower, 1981). Alternatively, the preconscious increase in processing resources which causes one to focus on emotional material could create a stronger nodal representation of the learned material, simply because it was more sharply attended to. The result is that it becomes easier to access the memory *a* at the time of recall.

Here a parenthetical explanation becomes necessary, for the distinction between mood and emotion is not clear in the literature. While some researchers define mood as a sustained and low-arousal emotion, others insist that the two represent categorically different phenomena. Richard Davidson explains the difference thus:

> Emotions most often arise in situations where adaptive action is required. Autonomic activity typically accompanies emotion and supports the action that coincides with the emotion…The primary function of moods, on the other hand, is to modulate or bias cognition. Mood serves as a primary mechanism for altering information-processing priorities and for shifting modes of information processing (cited in Ekman and Davidson, 1994, p. 53).

Davidson’s main distinction between emotion and mood thus seems to be the presence of physiological changes. He goes on to stipulate that, while “more enduring changes in the state of the central nervous system would be expected” in the presence of a mood, only emotion is accompanied by shifts in the autonomic nervous system (p. 53).

The question thus arises whether emotional state-congruent memory has the same effect as mood-congruent memory. Bower’s explanation of the phenomenon uses the two words – emotion and mood – interchangeably (Bower, 1981). Further, this model relies upon an affective state commandeering attentional resources, which is exactly the role that Davidson gives to mood: “altering information-processing priorities and…shifting modes of information processing." Given that both mood and emotion share this property, the difference between them may be moot in Bower's model.

Bower's cognitive theory can be linked with more neurological ones as well. Phelps & Sharot (2008) outlines the neural substrates for the memory advantage given to emotional items, focusing on the posterior parahippocampus and the amygdala. As Pessoa and others have pointed out, the brain deals with emotion in a very distributed fashion. In that vein, the amygdala appears to modulate the activity of the nearby hippocampus, thus influencing the "consolidation or storage of memories for arousing events, so that they are more likely to be retained over time" (Phelps & Sharot, 2008). Emotion also appears to alter the subjective sense of recollection. This trend is especially obvious in the case of flashbulb memories, memories with high emotional saliency (e.g. the terrorist attacks in New York and Washington, D.C. on September 11th) which are felt to be highly detailed and accurate, but which in fact can be very inaccurate when compared to objective accounts (Phelps & Sharot, 2008). Phelps and Sharot's study postulates that this subjective sense of the veridicality of emotional memory may have evolved to facilitate fast decision-making in an emotional context.

This behavioral evidence is also generally consistent with the neural connectivity between limbic areas like the amygdala and traditionally cognitive regions, such as the prefrontal cortex and the ventromedial prefrontal cortex. Evidence from lesion studies corroborates this view; for example, Spikman, et al. (2012) found that damage to the prefrontal regions inhibited social emotional processing.

Embodied Cognition

We turn now to the relationship between the cognitive and physiological representations of emotion. It is difficult to present a thorough review of this topic without mentioning embodied cognition, an area of cognitive science that has recently gained prominence in the literature. Broadly speaking, embodied cognition argues for an intrinsic link between mental processes and their manifestations in the physical body. This theory, following many other scientific models, rejects the Cartesian notion of a distinct body and mind (also known as Cartesian Dualism) and instead favors a view of the brain which does not stop in the skull, but reaches deep into the body through the peripheral nervous system. Susan Goldin-Meadow has applied this theory to gestures (Goldin-Meadow & Beilock, 2010; Broaders, et al., 2007) and others have investigated its wider implications for memory, perception, language comprehension, social cognition and basic thought (Barsalou, 2008).

Goldin-Meadow's work mainly addresses the role of embodied cognition in learning. Her 2007 study (Broaders, et al., 2007) explores the effect of instructing children to gesture while learning to solve math problems. The study found that children who had originally been unable to solve the problems but were then specifically told to gesture while learning soon incorporated new mathematical strategies into their work. These strategies were not expressed explicitly; instead, they were a form of implicit knowledge represented only in the gestures accompanying their speech. In addition, children in this intervention group were better at absorbing explicit knowledge about mathematical strategies. A later review of the topic (Goldin-Meadow & Beilock, 2010) surmised that gestures contain a surprising amount of information about the actions they represent. But they achieve than mere reflection: they also have the power to influence thought. In this way, gestures can be thought of as a bridge between action and thought.

Although emotion has not been explicitly studied within an embodied cognition framework, it can be useful to model it in that context. William James' original hypothesis is one of embodied emotion, for he proposes a strong link between the body's experience of emotion and the mental one which enters the conscious domain upon perception of physiological changes: "*the bodily changes follow directly the* PERCEPTION *of the exciting fact, and…our feeling of same changes as they occur* IS *the emotion*" (James, 1884). Embodied emotion may fall under the more general category of embodied cognition. For example, the elevated heart rate and perspiration that accompany fear are the embodiments and reinforcers of cognitive processes that analyze a dangerous situation (such as an approaching bear) and mobilize a behavioral response.

Barsalou (2008) cites two studies that found that making an emotional facial expression while reading emotional sentences enhanced participants' comprehension of the affective linguistic content (Havas, et al., 2007; Barrett, 2006). Barsalou explains this in terms of "affective simulation." Although he differentiates his theory of simulation and "grounded cognition" from embodied cognition (" 'embodied cognition' produces the mistaken assumption that all researchers in this community believe that bodily states are necessary for cognition and that these researchers focus exclusively on bodily states in their investigations...'Grounded cognition' reflects the assumption that cognition is typically grounded in multiple ways, including simulations, situated action, and, on occasion, bodily states"), his essential ideas closely mirror those of Goldin-Meadow, Broaders and other embodied cognitive scientists. Both frame the relationship between the body and the mind as one based in mental simulation of action. According to Barsalou, in order to comprehend emotional material one must mentally simulate the same affective state, which is why Skin Conductance changes when reading a taboo word. The embodiment of that simulation in the form of gesture or facial expression then has the power to influence thought. Of course, not all emotional words will necessarily elicit a physiological response.

Other studies involving physiological markers of emotion can be interpreted in the context of embodied cognition. This contextualization offers a fresh perspective on the relationship between emotion in the body and in the brain, but maintains the view that cognition, rather than the body, guides the embodiment. In 1962, Schacter and Singer conducted a now-classic experiment in which 101 participants received an injection of epinephrine (controls received a placebo) and sat in a room with an extremely angry or euphoric person while completing a questionnaire and rating their current mood and physical condition (Schacter and Singer, 1962).

Participants injected with epinephrine were divided into three groups: those who were ignorant of the effects of the shot, those who were informed that they would experience symptoms such as an accelerated heart rate, and those who were misinformed about the effects of the shot (e.g. that their extremities would grow numb). The authors measured emotional reaction in two ways: according to participants' self-report and according to experimenter observation of their behavior. Both the euphoric and angry conditions yielded significant differences in both measures between groups, especially between the informed and ignorant groups. Thus, the study found that, by heightening participants' physiological activity via the epinephrine and providing them with a cognitive context with which to label that physiological sensation, experimenters successfully influenced conscious perceptions of affective state.

According to Schacter and Singer's explanation, a general level of arousal *interpreted by cognition* translated to an emotional experience. However, this study's findings are tempered by the existence of confounds, such as the possibility that some participants were aware of the experiment's true purpose. In addition, several of the control subjects reported an emotional response, a hitch that throws the role of the epinephrine into doubt. Nevertheless, Schacter and Singer's experiment provides a useful method of conceptualizing emotion and the body which is distinct from the James-Lange theory because the latter states that no cognitive appraisal is necessary in order to experience an emotion. While it seems relatively clear that a bodily state can modulate cognitive processes and vice versa, the issue of whether physiology is capable of initiating an emotional process remains murky.

The Facial Feedback Hypothesis

The Facial Feedback Hypothesis (FFH) can be considered a version of embodied cognition. However, the crucial difference between embodied cognition as expressed by Barsalou and Goldin-Meadow, and the FFH, is that embodied cognition maintains that mental processing initiates the process, even if the processing is not conscious. The FFH makes no such claim, and instead refers to a group of theories which broadly predict that facial expression affects the conscious experience of emotion. Under the strongest version of this hypothesis (the sufficiency hypothesis), the emotional face is capable of producing an emotion without other stimuli, though this face is not necessary in order to feel the emotion (Hess, et al., 1992). In contrast, the necessity hypothesis predicts that facial action is required for an emotional experience (but is not necessarily capable of prompting an emotional response on its own). For example, the necessity hypothesis predicts that sadness could not be consciously felt without a simultaneous sad facial expression; however, the face alone, without any additional stimulation from the environment, could not prompt the emotion (Hess, et al., 1992).

This last interpretation of the FFH predicts that a person whose face was paralyzed could not experience emotion. Davis, et al. (2010) tested this prediction by injecting participants' faces with either Botox (BoNT-A) or a placebo (HA) and evaluating self-reports of emotional experience after viewing affective film clips. The results indicated that, while BoNT-A participants showed no within-subjects difference between emotional report before and after treatment, they did give significantly less intense emotional ratings than controls injected with the placebo.

This second result seems to support the necessity hypothesis; however, the first result does not, for experimenters expected a within-subjects effect of facial paralysis and none of the participants had undergone a similar procedure before. In addition, it is unclear whether the second result reflects an interesting change in the BoNT-A group. The authors speculate that this result could be explained by small alterations in both groups' ratings between sessions. The methods of the study also precluded the possibility of randomly assigning participants to experimental conditions, because participants chose their condition. As a result, it is impossible to tell whether the study's results depended in part upon demographics or baseline differences in groups.

Finally, the monotonicity hypothesis posits a monotonic[1], positive relationship between the intensity of the expression and that of the emotion (though the causation of this relationship remains unclear). Thus, a more intense or dramatic emotional facial expression should coincide with a more intense emotional experience. The monotonicity hypothesis is not mutually exclusive of the other versions of the FFH, but it is a much milder interpretation. Only this last version of the FFH has received consistent support from research, though critics have been prolific in responding to such findings (Hess, et al. 1992). Common complaints include the fact that most studies have only tested one negative and one positive emotion, rather than including

[1] A monotonic relationship is one that does not change its direction over a given period. For example, a monotonic two-dimensional graph could increase by sloping upwards or maintaining a flat slope, as long as it does not decrease over the relevant interval.

multiple emotions from each category, such as sad, angry, happy, surprised, etc. (Winton, 1986). Others point out that too many studies have relied upon self-report as the major dependent variable, leading to the possible influence of experimental demand on results. Finally, the repeated failures to replicate studies of the FFH only strengthen the skeptics' arguments.

In spite of these criticisms, several studies yielded interesting results regarding the cognitive effects of facial expression. Mori & Mori (2010) found that stretching elastic bands across participants' foreheads so that their brows either involuntarily wrinkled or remained smooth affected affective judgments of neutral Tibetan characters. On the other hand, Reisenzein & Studtmann (2007) found that participants who unconsciously mimicked a surprised expression rated mood and emotion terms no differently than when their faces remained neutral. These authors questioned the validity of the FFH, and instead posited that the "reverse self-inference hypothesis" might effectively explain their results. Under this hypothesis, participants asked to identify their emotional state while undergoing a facial manipulation do not answer based on feedback from their facial expression, as the FFH would predict. Instead, they infer their facial expression based on their emotional state, effectively reversing the assumed direction of the relationship between awareness of facial expression and awareness of emotion.

It is unclear whether this theory is opposed to Ekman's. While Ekman argues that a facial expression catalyzes autonomic responses which cause conscious awareness of emotion, the reverse self-inference hypothesis predicts that people only refer to their faces *after* beginning to experience an emotion, rather than experiencing an emotion because they have noticed their facial expression. This may fit into Ekman's model, though he makes no mention of such a process.

Dimberg and Söderkvist (2010) found evidence for a modulating role of facial expression, but nothing which indicated that the face initiated emotion. In their study, participants rated the pleasantness of emotional and neutral stimuli while either smiling or frowning. Results indicated that the ratings of emotional stimuli were augmented by the emotional face condition, whereas ratings of neutral stimuli remained unaffected. Thus, an emotional expression could not create an emotional interpretation when there was no additional emotional stimulus.

The summation of this research indicates uneven evidence for the Facial Feedback Hypothesis. However, it seems that an emotional expression can have an effect on some cognitive tasks (primarily picture ratings), especially when emotion is already present in the stimuli. It is also unclear what mechanisms govern facial feedback, and how that feedback interacts with cognition. For example, Schacter and Singer (1962) theorized that general physiological arousal (of which facial action is one component) generated the intensity of an affective experience and cognitive appraisal processes produced the awareness of the specific emotion. As we have seen, Ekman has a more specific explanation of this mechanism, involving activation of the facial nucleus or the motor cortex causing conscious emotion.

The Current Study

The current study fills a conspicuous gap in Ekman's research on facial action by investigating the effect of facial expression on memory. Specifically, it tests for the Mood Congruent Memory (MCM) effect following the DFAT for the happy and sad emotions. According to MCM, memory for mood-congruent items is increased compared to that for incongruent items (e.g. Bower, 1981; Vuoskoski and Eerola, 2012;). Based on Ekman's claims, we predict that the data will show MCM when participants are induced into a mood using the

DFAT. MCM will be measured as the difference between recall for mood-congruent and mood-incongruent items under each mood condition.

Further, given that Ekman argues that the DFAT initiates an emotional response by way of a physiological mechanism, we expect that autonomic activity, as measured by Galvanic Skin Response (GSR) will correlate with MCM and that GSR will significantly differ between the happy and sad emotional conditions.

METHODS

Participants. 38 Claremont Colleges students participated in this study in exchange for $10 and were included in the final analysis (27 F, 11 M; mean age = 20.05). GSR was recorded for 21 of these 38 (14 F, 7 M). Participants taking anti-depressants were excluded from the analysis, based on findings that serotonin-reuptake inhibitors can alter emotional functioning, and thus these participants' results might not reflect the normal emotional processes linked with memory and cognition. Only subjects who were able to complete a preliminary facial action test participated in the full study (one subject was excluded based on this criterion).

Materials and Apparatus. All participants completed a consent form and personal information sheet, which prompted them to identify their age, sex, education level, past neurological conditions, current medications, and rate their current mood on a scale from 0 (very negative) to 8 (very positive). Stimuli included two memory lists with 5 negative (sad), 5 positive (happy), and 9 neutral images taken from the International Affective Picture System (IAPS). See Table 1 for a breakdown of valence and arousal ratings by emotion category.

Initial piloting of 15 participants (9 females, 6 males; mean age = 19.73) verified the predicted memory advantage of emotional over neutral images. As a result of this piloting, the two lists were slightly altered in order to contain equal amounts of emotional content, using memorability as a basis. Both lists began and ended with two neutral filler images to control for primacy and recency effects. Positive, negative and neutral images were randomly ordered. The lists were presented using Microsoft Powerpoint on a Macintosh or PC desktop computer and a tone accompanied the first and last images (to aid video analysis and serve as a ready signal to the participant). Each image remained on the screen for 1.5 seconds.

A built-in “iSight” camera on a Macintosh desktop computer recorded facial movements for participants whose GSR was not measured. Two adjustable, wall-mounted cameras recorded the same information from GSR participants. A Biopac system, including electrodes, reusable leads, an adapter cable and a chassis, measured Galvanic Skin Response. This system communicated with an experimenter-controlled PC (located in a separate room) running EDA software to analyze the GSR data. E-Prime synchronized timings between the Biolab system and stimulus presentation. An intercom was also used to communicate with the participant when necessary.

A mood-rating survey consisted of the following questions: “Did you feel any emotions? (yes or no)”, “If so, how intense was it (0-8 scale)?”, “How positive or negative was it (0-8)?” and “Can you identify the emotion?” Finally, distracter tasks employed the Nelson-Denny vocabulary test and word searches developed in the lab.

Procedure. All participants began by signing a consent form and completing an initial mood-rating survey, appended to the personal information sheet. The experimenter then explained that the study would include facial movement, and read out some warm-up facial exercises (e.g. “wrinkle your nose,” “pull the inner corners of your eyebrows together”), both in order to allow the participant time to practice and in order for the experimenter to evaluate the participant’s ability to complete the DFAT. Each participant was randomly assigned to a DFAT condition order and a list order, so that both were counterbalanced across participants; thus, while Subject (a) saw list #1 during the sad condition and list #2 during the happy condition, Subject (b) saw list #2 during the sad condition and list #1 during the happy condition.

Hand electrodes used to measure GSR were attached via adhesive pads to the participant’s non-dominant palm (after washing their hands with non-abrasive Softsoap and allowing the experimenter to clean the area with isopropyl alcohol). The experimenter then instructed the participants via intercom to manipulate their face into a “neutral” position with the help of experimenter feedback (see Table 2 for specific instructions).

The facial manipulation followed the following procedure adopted by Levenson, Carstensen and Ekman (1991). The participant was instructed to hold a neutral face for 15 seconds. During this period, Biolab recorded the participant’s baseline GSR. After holding this face, participants assumed the relevant emotional face (see Table 2). The experimenter provided additional feedback as needed. Participants held this emotional face for 15 seconds, while emotional GSR was recorded. Participants then continued holding the expression while first completing the mood rating survey and then viewing a list of 19 IAPS images (5 sad, 5 happy, 9 neutral). The experimenter began the presentation on the participant’s signal.

Immediately after this presentation, participants relaxed their face and completed a two-minute vocabulary test in order to provide interference. After this test, they completed a free recall task, which lasted a maximum of three minutes. The instructions for the recall task were the following:

> “For each remembered image please write down a descriptive phrase, or a few words. These should be of sufficient detail to allow the researcher to distinguish which image you remember from all other images, however a very full and detailed description is not necessary. It is important that you report every image that you can remember. Try not to leave out any image even if you start to feel that you are guessing.” (Taken directly from Pottage and Schaefer, 2010).

Participants then reported their current mood (on a scale from 0-8). If their mood was not neutral (4), they completed a 1-minute word search distracter task and then re-reported their mood before moving on to the next condition. If this mood did not change, it was considered stable and unlikely to change through the use of further interference tasks.

After participants had completed both conditions, the experimenter debriefed them about the purpose of the study and thanked them for their time. Subjects who performed well on the DFAT during the non-GSR Facial Action study (2 faces scoring 3 or higher according to the Facial Action Coding System) were invited back for an abbreviated procedure, in which they held the same faces while their GSR was recorded and then completed a mood-rating survey and a between-conditions distracter task (a 2-minute word search), but did not complete the memory task (N=5, 2M 2F).

RESULTS

Self-Report data

Table 3 shows participants' mean ratings of the valence and intensity of their mood, as well as the change in valence between the emotional condition and a baseline mood. However, these averages are not a perfect reflection of emotional responses because the direction of valence change was not consistent between subjects. While 28 out of 32 participants who reported a mood indicated a negative change in valence in the sad condition, 12 out of 25 did so in the happy condition. A paired-samples t-test comparing intensity ratings found no significant difference between the happy and sad conditions ($t(36) =-.31$, $p =0.76$). Table 4 includes information about the emotional labels that participants gave to their moods in the happy and sad conditions, and compares participants' accuracy in identifying the target emotion to previous studies using the DFAT.

Facial Quality data

Faces were scored according to the method outlined by Ekman (2007) (see Table 2 and Appendix B). Video records of the 15-second period during which participants held the emotional face were scrutinized in order to assign a score of 0 – 4, with 4 indicating the highest possible quality and greatest ecological validity. The mean quality score was 3.15 in the happy condition and 2.91 in the sad condition. A paired-samples t-test found a trend but no significant difference between facial quality scores in the happy and sad conditions ($t\ (32) = 1.76$, $p = 0.09$), with lower mean facial quality scores in the sad condition. We can thus speculate that sadness may have been more difficult to simulate facially than happiness. All participants' data were included in the final analysis, regardless of facial quality. Quality of facial expression correlated positively with reported change in mood valence rating for the sad condition in a one-tailed Pearson's correlation, $r\ (31) = 0.31$ ($p<0.05$) but not the happy condition, $r\ (31) = 0.03$ (p=n.s.).

Changes in mood valence were signed, and the average change was -2.80 in the sad condition and -0.06 in the happy condition (see Table 3). The positive correlation thus indicates that a lower-quality facial score correlates with a more dramatic decrease in mood valence.

Physiological data

Reactivity of GSR was calculated by finding the change between GSR recorded while participants held a happy or sad face for 15 seconds, a neutral face. The average change in GSR from the neutral to the emotional face was +0.05 microsiemens in the happy condition and +0.11 microsiemens in the sad condition. The direction of GSR change scores did not vary with condition, as evidenced by an insignificant paired-samples t-test comparing GSR change scores in the two conditions (t (20) = -.30, p = 0.77). However, direction of GSR change did vary between participants. A paired-samples t-test comparing GSR during the neutral face and that during the emotional face found no significant difference between autonomic activity before and after the DFAT in either mood condition (t (20) = -0.31, p = 0.76 for happy, t (20) = -0.71, p = 0.49).

A 2x2 (sex x mood) ANOVA was conducted to determine whether either participant sex or emotional condition had an effect on GSR. There were no significant results (F(1, 19) = 0.869, p = n.s. for sex, F(1,19) = 0.040, p = n.s. for mood, F(1,19) = 0.002, p = n.s. for sex x mood interaction). However, planned one-tailed Pearson's correlations revealed some trends. Reported change in mood valence showed a trend correlating with change in GSR in the happy condition, r (19) = 0.32 (p = 0.08), but was far from significance in the sad condition, r (19) = -0.06 (p=n.s.).

Mood-Congruency data

Recall rates were calculated as the proportion of pictures correctly recalled out of total pictures presented in each emotional category (positive, negative or neutral). Table 5 shows proportional recall by picture type and emotional condition. The mood-congruent effect on memory was evaluated by finding the difference between recall for mood-congruent and mood-incongruent items under each mood condition. Table 5 proportional recall rates for positive, negative and neutral pictures in the happy and sad conditions.

In order to determine the effect of picture type and mood condition on recall rates, a 2 x 3 (mood x picture type) ANOVA was conducted on the dependent variable of proportional recall of emotional pictures. This ANOVA indicated a significant main effect of picture type ($F (2, 37) = 46.08$, $p < 0.001$), replicating the expected memory advantage of emotional over neutral items, but no main effect of emotional condition and no interaction.

Independent-samples t-tests were run to determine whether the mood-congruency effect differed between participants who identified the target emotion and those who did not. Even using a liberal interpretation of target identification (i.e. whether the identified emotion was positive in the happy condition and negative in the sad condition), this test yielded insignificant results for both the happy ($t (27) = 0.61$, $p = 0.27$) and sad ($t (27) = 1.15$, $p = 0.13$) conditions, indicating that identification of the target emotion did not increase the cognitive effect of mood-congruity.

One-tailed Pearson's correlations were conducted to determine whether significant relationships existed between variables of emotional and cognitive response. Reported change in mood rating correlated positively with the mood-congruent effect in the sad condition, $r (19) = 0.28$ ($p<0.05$) but not in the happy condition, $r (16) = -0.09$ (p=n.s.). All correlations between change in GSR and difference in recall for mood-congruent and mood-incongruent items were insignificant ($r (19) = -0.07$ for sad condition, $r (18) = -0.04$ for happy condition, p=n.s. for both).

Independent-samples t-tests comparing mean proportional recall between participants who identified the target emotion and those who didn't found no notable difference in means in the happy condition ($t(19) = 1.094$, $p = 0.144$) or the sad condition ($t(19) = -0.210$, $p = 0.418$). These results did not improve when a more liberal interpretation of "correct identification of the target" was applied (see above). These results reveal that reporting an experience of the target emotion did not affect autonomic response as measured by GSR.

DISCUSSION

The results described above support five main findings. First, there was a significant positive correlation between facial quality score and change in self-reported mood valence in the sad condition. Second, change in self-reported mood valence correlated marginally with change in GSR in the happy condition. Third, a 2 x 3 (mood x picture type) ANOVA found a significant main effect of picture type, without any effect of mood. Fourth, change in self-reported mood valence was significantly and positively correlated with a mood-congruent effect on memory in the sad condition. Fifth, all statistical tests failed to find a significant relationship between the cognitive effect of mood-congruent memory and the physiological effect of change in GSR.

This study's results have several interesting implications for the current scientific understanding of emotional physiology, especially regarding Ekman's work on facial action. Ekman's theory hinges on the assumption that physiological arousal, precipitated by changes in facial musculature that occur in the DFAT, causes the conscious experience of a given emotion. This study investigated whether this emotion is also capable of causing the memory changes historically associated with emotion in the scientific literature.

Emotion Specificity

Levenson, et al. (1990) argues that each emotion has a distinct autonomic "signature," which allows the brain to determine which emotion the body is experiencing based solely on physiological information. This study examined only two emotions rather than the customary six; however, given that the current contrast was between a positive and a negative emotion, the autonomic data were expected to differ significantly between conditions, as has been found in previous studies (e.g. Levenson, et al., 1990, Carstensen, Levenson & Ekman, 1991).

However, this was not the case. There was no significant difference between GSR changes between the happy and sad emotional conditions. While this may be due to the use of only one autonomic measure, this null result indicates a need within the scientific community to replicate Levenson, et al. (1990)'s result in order to definitively establish a link between facial action and an emotion-specific physiological signature. The current study also found no significant difference between baseline GSR and emotional GSR, indicating that the DFAT did not initiate any physiological changes.

Reality of Emotional Experiences

The conscious experience of an emotion was measured using self-report. Participants were asked to rate the valence and intensity of their current emotional state both before completing the DFAT and after holding the emotional face for 15 seconds, and to identify the emotion they had experienced after holding the emotional face. Self-reported valence change appears to be a better measure of a mood than ability to supply a label to identify the mood, perhaps because the latter relies more heavily upon conscious guess-work. Participants who identified the target emotion did not show any increase in GSR change over those who did no, nor did those who identified the intended emotional valence (positive or negative). This indicates that the changes in GSR failed to prompt the conscious experience of emotion. However, the fact that GSR marginally correlated with self-reported mood changes in the happy condition suggests the existence of some components of a consciously and physically experienced emotion.

This same trend between GSR and self-reported mood changes was not evident in the sad condition, likely because sadness is a relatively low-arousal emotion. This may imply that sadness is a difficult emotion to bring to consciousness based solely on physiological changes. When compared to fear or anger, for example, sadness is much more cognitive and less tied to an evolutionary advantage than the higher-arousal negative emotions (Robert Levenson in Ekman & Davidson, 1994, p. 256). The DFAT, which relies upon autonomic changes to catalyze conscious emotions, may thus be less effective in causing sadness. If this is true, it challenges Ekman's theory that *all* universal emotions are tied directly to physiology.

Physiology and Cognition

If it is true that Ekman's facial action task is capable of producing an emotional response through a manipulation of physiology alone, we would expect to see a significant relationship between autonomic changes and cognitive changes in mood-congruent memory. However, this was not the case. There were no significant correlations between GSR change scores and mood-congruent memory measures in either emotion. As discussed above, this is most likely because the facial action task simply failed to produce any changes in participants' physiological state. However, the data do show a significant correlation between self-reported change in mood and mood-congruent memory in the sad condition.

The asymmetry of this pattern, occurring only in the sad and not in the happy condition, may be due to the inherent memory advantage of negative material. Evidence suggests that the enhanced saliency of negative items tends to give them an advantage in memory over positive or neutral items even without an emotional context (e.g., Pratto and John, 1991). Although the current study's stimuli were chosen in order to control for differences in arousal and distinctiveness between the positive and negative groups, the recall data (Table 5) indicate that negative pictures retained an advantage in memory. Thus, the mood-congruent effects of a negative mood may amplify this difference even further, whereas positive items do not have enough of an initial advantage for the relationship to reach statistical significance.

Interestingly, the data also revealed a positive correlation between facial quality score and reported change in mood. Ekman uses a similar result in his own studies to suggest that a more successful manifestation of the facial action task causes a more intense emotional experience. One possible alternative explanation for this result is that the sad face was simply more difficult and unpleasant to hold, while the happy face was easy to make. According to this argument, the subsequent mood ratings reflected the effects of muscular comfort rather than the intended emotion-specific effects. Indeed, there was a trend difference between sad and happy faces' quality scores that indicates that this may be true. Another possible explanation is that the facial action task may have had an emotional effect, but through cognitive rather than physiological means. It is possible that participants' moods were affected by their recognition of the expression on their own faces, and as a result of that realization experienced some weak effects of mood-congruency on memory.

This explanation is inconsistent with Ekman's theory, because he assumes that emotional changes come about as a result of physiological alterations; however, he does admit that facial musculature is only a small part of emotional physiology, though he still hypothesizes that it is powerful enough to elicit an emotion. A more probable explanation reverts back to the cognitive appraisal mechanism supported by the Schacter and Singer (1962) study. According to this theory, conscious emotion is the result of a combination of cognitive appraisal and physiological arousal. Cognitive appraisal might consist of the perception of emotional stimuli in the environment, such as a crying child or a tranquil beach scene, and the subsequent top-down evaluation of those stimuli based on prior experience (episodic memory) and general knowledge of the world (declarative memory). Perhaps having one of these two elements – either cognitive appraisal or autonomic arousal – is sufficient to prompt weak emotional responses.

Methological Anomalies

The data from this study revealed much individual variation in GSR change scores, both in magnitude and direction. Several participants' GSR changed in a negative direction in one condition and in a positive direction in the other, but there was no evidence indicate that this variation was due within condition. The differences in direction are especially interesting, for there is essentially no mention in the literature of negative changes in GSR in the presence of an emotional stimulus. The assumption in physiological studies seems to be that all such changes will be in the positive direction. It thus remains unclear why some participants would exhibit a negative change

In addition to these unexpected data, the reliance on self-report to indicate mood changes is flawed because such a measure is susceptible to experimental demand and other confounds (e.g., Davies and Best, 1996). However, there is no viable alternative to the use of self-report, and this method did supply useful data (such as the significant and marginally significant correlations between self-reported change in valence and facial quality score, the mood-congruent effect on memory and change in GSR) in the absence of significant changes to physiology.

Theoretical Implications

The results of this study raise some difficult questions for Ekman's theory of physiologically-prompted emotion. The study's primary motivation was to determine whether the physiological changes resulting from the DFAT were powerful enough to affect memory.

The results suggest that, at least in the cases of happiness and sadness, they were not. There is no evidence of a mood-congruency effect on free recall of emotional pictures. This may imply that mere physiological changes do not extend as far as naturally-occurring emotions into the cognitive mechanisms of attention and memory. This may simply be because, without the aid of cognitive cues in the environment to further inform a person's understanding of his or her emotional state, it is less likely for the physiological changes that coincide with a particular emotion to rise to consciousness. As was mentioned in the introduction, there is a great debate concerning whether an emotion can be non-conscious. But assuming that it can, perhaps such a non-conscious emotional state is less capable of affecting memory than a conscious one. If this is accurate, the lack of evidence for mood-congruent memory in the present study could be due to a failure of physiological changes motivated by the DFAT to manifest as a *consciously* experienced emotion.

It is also problematic that so few people identified the target emotion when asked to label their current mood. If Ekman is to claim that emotional physiology is specific enough to leave a unique signature on the brain, and that the effect is one of *conscious* emotion, a higher percentage of participants should be able to identify the target emotion. In the current study, this failure was likely due to the weak physiological effects as a result of the DFAT. However, Ekman's own studies (e.g. Levenson, et al., 1990; Carstensen, et al., 1991) find similarly low rates of accuracy among self-reported emotional labels (see Table 4). These results are rationalized by arguing that, as long as participants identified the target emotion more than one sixth of the time, the effect is valid. Ekman arrives at this figure by reasoning that, given that there are only six universal emotions, participants have a one in six chance of guessing the correct emotional label. However, this figure of one sixth depends upon the validity of Ekman's theory of six universal emotions, the existence of which is nearly impossible to prove scientifically. In this case, the use of one sixth as a cutoff is simply convenient to Ekman's preferred interpretation of the data. Participants' low accuracy rates in the current study and in Ekman's own research cast any universal generalizations made on the basis of such data into doubt.

This study also found that a surprising number of people were unable to perform elements of the DFAT, especially movements (such as "raise the inner corners of your eyebrows") given crucial importance by Ekman's scoring system. Further consultation of his published studies revealed that Ekman commonly required participants to pass a screening test to ensure that they were capable of making the facial movements required by the task. In one study, only 30 out of 119 participants (25.2%) passed this test. If nearly 75% of this particular population was unfit to perform the DFAT, does this imply that Ekman's theory only applies to a small sub-section of the population?

Given the shortcomings of Ekman's emotional theory, an alternative view may be outlined. In this alternative model, both the top-down cognitive cues of the emotional environment and the bottom-up cues of automatic physiological changes inform the conscious experience of an emotion. Some sort of pre-conscious mechanism must be postulated to perceive something in the environment that justifies an emotional reaction and then initiate any sort of emotional arousal to begin with. Following this, the attraction of the emotional object or situation would stimulate both cognitive and physiological changes, which may converge at some point and together spark a conscious experience. It is possible that either physical or cognitive mechanisms in isolation could prompt some sort of weak emotional response. However, this study's introduction mentioned research on the Facial Feedback Hypothesis which concludes that participants experience emotion more strongly when their facial expression matches the emotion. According to these findings, co-occurrence of emotional physiology and cognition would serve to enhance the experience of emotion. Further, such a situation would rarely occur in a natural setting, so such a caveat is not applicable to most emotional experiences in humans.

Future Directions

In future studies, it would be valuable to test more arousing emotions, such as fear or anger, in order to enhance the possibility to measuring significant differences in emotional physiology. In the same vein, the use of multiple physiological measures, such as heart rate and respiration, in addition to GSR would be relatively simple given the correct equipment and more capable to painting a full picture of participants' physiological reactivity.

Another interesting manipulation would be the addition of a second experimental group that experienced a cognitive method of emotional elicitation, such as exposure to an emotional film or a guided recall task. This design would essentially replicate that adopted in Carstensen, et al. (1991), which compared physiological changes after a guided emotional recall task and after the facial action task. However, the addition of a cognitive measure, such as mood-congruent memory, would help to complete the theoretical manifestations of this study.

Conclusions

This study's findings cast the methodologies relied upon in such fundamental studies as Levenson, et al. (1990) and Carstensen, et al. (1991) into doubt. Ekman's theory of physiologically-motivated emotional experience must thus be viewed as resting on somewhat shaky ground. Although the current study's failure to find an effect of the DFAT on memory could be due to a failure to provoke physiological changes, its findings regarding the nature of emotional self-report and labeling of emotions suggest that previous studies may not have succeeded in finding a generalizable and ecologically valid effect of facial action on the conscious experience of emotion.

TABLES AND FIGURES

EXPERIMENTAL STIMULI

Table1: Mean valence and arousal ratings for IAPS images in both lists[1].

Emotion	Mean Valence	Mean Arousal
Sad (N=10)	2.99	4.51
Happy (N=10)	8.11	4.55
Neutral (N=18)	5.12	2.91

[1]Taken from IAPS standardized ratings. Both Valence and Arousal are measured on a scale from 1(least pleasant/least arousing) – 9 (most pleasant/most arousing)

Figure 1. Sample experimental stimuli from the International Affective Picture System (IAPS). From right to left: Happy, Sad, Neutral

THE DIRECTED FACIAL ACTION TASK

Table 2: DFAT Instructions[1].

Emotion	**Instructions**
Neutral	Close your mouth and puff your cheeks out gently and close your eyes.
Sad	Raise the inner corners of your eyebrows and pull them up and together in the center of your forehead. Pull the corners of your lips down. Raise your cheeks and pull your lip corners up against the downward pull. Glance down.
Happy	Raise your cheeks. If it is hard to do try squinting a little. Part your lips and let your lip corners come up.

[1]Instructions copied from Levenson, Carstensen & Ekman (1991)

Instructions for scoring faces (from Ekman, 2007):

"0 = WORTHLESS…The subject couldn't do any of the critical Action Units (AUs); or the subject did the wrong emotion; or the subject included AUs which would almost certainly make it a blend with another emotion.

1 = POOR…About the worst performance you could see and still not want to throw it away. It could be bad because they had such a hard time doing it and couldn't hold it for more than a second. Or it could be that not all of the critical AUs were included (and by that I don't mean all

of the AUs we asked for, but the ones that we think are most important). Or it could be that they included some other AUs which might cause a blend, but you can't be absolutely sure.
2 = FAIR…No real problem other that [sic] it isn't great. There is no problem of a blend, and it might include the most important AUs, but it isn't really good. It might have taken a long time to get it or not be held the whole time. An important AU like AU5 might drop out after a second or two. If a face with all critical AUs is performed with no blend AUs, the rating should be at least 2, even if the AUs fade before the end of the trial.
3 = GOOD…All the critical AUs are performed, and it wasn't an ordeal getting him or her to do it, and it held most of the time. Nothing wrong with it but it isn't the best you have seen.
4 = EXCELLENT…One of the best performances. Done readily, held throughout, all of the AUs asked for. Convincing job."

Critical Action Units (AUs) for Happiness and Sadness:
Happiness: 6 ("Cheek Raiser," involves the orbicularis oculi, pars orbitalis) + 12 ("Lip Corner Puller," involves the zygomaticus major)
Sadness: 1 ("Inner Brow Raiser," involves Frontalis, pars medialis) + 4 ("Brow Lowerer," involves corrugators supercilii, depressor supercilii) + 6

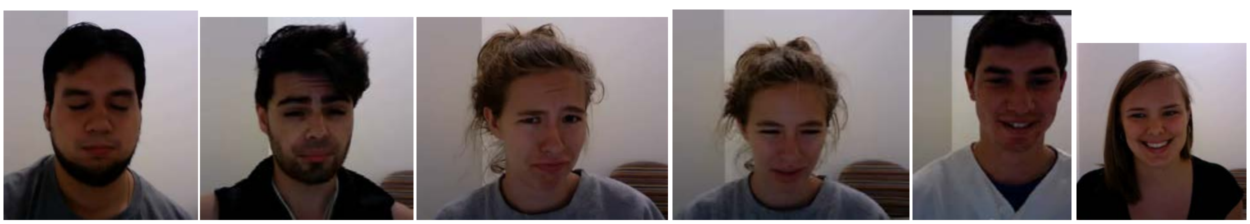

Figure 2. Examples Face images. From left to right: (1) neutral face, (2) sad face with score of 4, (3) sad face with score of 3, (4) happy face with score of 2, (5) happy face with score of 3, (6) happy face with score of 4 (all images used with consent of participants)

Table 3: Means and Standard Deviations of Self-Reported Mood Ratings by Participants' Mood

	Happy[1]	Sad[2]
	M (SD)	*M* (SD)
Valence[3]	5.5 (1.4)	2.8 (1.2)
Intensity	3.2 (1.8)	2.9 (1.3)
Change from Baseline[4]	-0.06 (2.0)	-2.8 (1.9)

[1] N = 25 [2] N = 32 [3]Valence and Intensity were rated from 0 (most unpleasant and least intense) to 8 (most pleasant and most intense) [4] Calculated as self-reported valence in the emotional condition – self-reported valence in a neutral condition

Table 4: Number and Percent of Participants Using Emotional Labels

	Emotion				
	Happy		Sad		All Emotions
	Current Study: Raw Number	Current Study: Percentage	Current Study: Raw Number	Current Study: Percentage	Levenson, et al. (1990): Percentage[1]
Total Participants	38	-	38	-	-
Participants Who Gave a Label	18	47%	21	55%	62.4%
No Label	20	53%	17	45%	37.6%
Target Label	10	56%	5	24%	35.4%
Positive Label[2]	10	56%	10	48%	-
Negative Label	2	11%	1	5%	-
Miscellaneous Label[3, 4]	8	44%	11	52%	-

[1] Averaged from three experiments presented in Levenson, et al. (1990). These results were not broken down by emotion, so the percentages in the table are an average of self-reported labels for all 6 of Ekman's emotions [2]Includes "amusement" and "nonchalance" [2]Includes "silliness" and "indifference" [3]Percentages for each condition add up to over 100 because some participants included multiple labels for each emotion.

Table 5: Mean Proportional Recall Rates by Picture Type and Emotional Condition of the Participant

		Emotional Condition	
		Happy	Sad
		M (SD)	*M* (SD)
	Positive	0.49† (0.20)	0.47 (0.21)
Picture Type	Negative	0.57 (0.21)	0.58† (0.20)
	Neutral	0.27 (0.20)	0.29 (0.16)

† Denotes mood-congruency between emotional condition and picture type

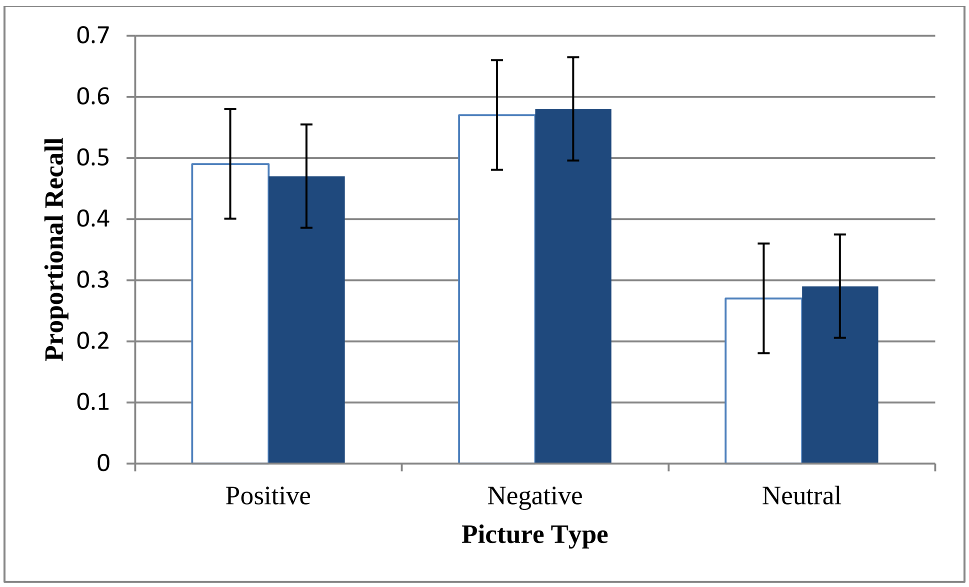

Figure 3. Chart of the relationship between picture type (x-axis) and proportional recall (y-axis) by emotion. The white columns represent recall in the Happy condition and the blue columns represent recall in the Sad condition.

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