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Do Emotion Words Influence Age Effects in Delayed Match-to-Sample Performance for Emotional Faces?

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DO EMOTION WORDS INFLUENCE AGE EFFECTS IN DELAYED MATCH-TO-SAMPLE PERFORMANCE FOR EMOTIONAL FACES?

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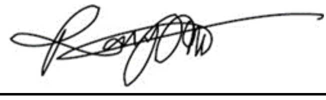

Associate Provost for Research and Graduate Education

謹將這篇論文獻給我在天上的母親楊繼鑫女士，妳教我勇於追求夢想，使我成為更好的人。也獻給我的外婆黃桂美女士，感恩妳對我的培養與無盡包容。我愛妳們。

I dedicate this thesis to my mom in the heaven, Ji-Shi Iang, who taught me to be brave and follow my heart. I also dedicate this thesis to my grandmother, Gui-Mei Huang, who shared her unconditional love and patience with me. I love you forever.

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Age differences are apparent in using verbal labels of emotion to categorize emotion face stimuli. Particularly, older adults have more difficulty detecting emotion cues like anger and fear relative to younger adults, but seem to have less difficulty with disgust cues. However, age differences are diminished in situations when participants are limited to two possible emotion choices or are required to simply match stimuli based on emotion cues without the use of labels. One question that emerges from the disparities in these findings is the role that emotion labels themselves play in driving possible age differences in emotion perception. The current study asked younger and older adults to perform a match-to-sample task in which, after being primed with an emotion label, they observed a mixed emotion stimulus (e.g., combination of anger and disgust) and then indicated which of two face standards was identical to the original stimulus. The standards were manipulated such that, paired with the original stimulus, participants also observed a second standard that was dominated by one of the emotions found in the initial mixed emotion stimulus. Should participants be primed by the dominating emotion, they would be more likely to misremember the initial stimulus by choosing the standard stimulus with a stronger emotional signal for the emotion specified in the word prime. The results showed similar performance among the control condition and the conditions of different dominating emotion in both age groups, indicating that younger and older adults relied on facial cues from the initial stimulus rather than the conceptual information found in the

word primes to match the standard stimulus to the target. While age differences were limited, a correlation analysis demonstrated that fluid cognitive abilities may matter more to older adults' performance than to younger adults' performance in the memory task. Additional questions were also discussed for future studies to address and fully understand how exactly lexical stimuli might influence face perception and memory performance in a delayed match-to-sample task.

Introduction

The ability to recognize emotion supports successful interpersonal functioning. Emotional expressions usually reflect people's inner states, and understanding people's inner states helps us choose appropriate strategies for communication. Although reading others' emotional expressions is crucial and it happens frequently and naturally in our daily life, past studies have shown that younger and older adults do not necessarily process emotions in an identical manner. This sometimes contributes to older adults' errors in judgment in the lab. The ways in which emotion recognition processes change across the lifespan have been studied using diverse methods (Isaacowitz & Stanley, 2011). While many studies have contributed to our understanding of age-related changes in emotion recognition, a number have focused on assessing age differences by asking members of different age groups to apply a selection of emotion labels when evaluating expressions (e.g., Calder et al., 2003; Isaacowitz et al., 2007; Ruffman, Halberstadt, et al., 2009; Suzuki et al., 2007; Wong et al., 2005). Other studies using label-free emotion perception tasks (e.g., Mienaltowski et al., 2018; Sullivan & Ruffman, 2004) revealed results that are partly inconsistent with these labeling-focused studies. What role exactly do the labels that we use to categorize emotion play in what we see when perceiving emotion cues on faces? How people recognize others' emotions remains a topic of intense interest today (Barrett et al., 2019). The current study aims to investigate how different age groups perceive emotions and what role emotion labels play in the perception process.

Literature Review

Emotion Classification

The number of emotions that humans display and can recognize is still an empirical question. One classic view for emotion classification is Ekman's basic emotions (Ekman & Friesen, 1971); this view characterizes emotions as being discrete and adaptive (Ekman & Cordaro, 2011). The term discrete suggests that emotions can be fundamentally distinguishable from one another using facial, vocal, autonomic physiology, and situational determinants. For example, an interculturally comparative study of emotion experiences in 37 countries found that some English emotion terms can be translated into various languages (see Ekman & Davidson, 1994). Also, people in Western countries can well recognize certain Western facial expressions, as these expressions typically precede the same emotionally toned event regardless of country of origin (e.g., feeling fearful after suddenly losing a physical support and/or falling down) (Ekman & Davidson, 1994). Another characteristic of "being basic" is that emotions have evolved through adaptation to our surroundings. Biological mechanisms help us to quickly and automatically react to fundamental life events, such as losses, frustrations, successes, and joys (Ekman & Cordaro, 2011; Ekman & Davidson, 1994). Thus, emotions are not simply positive or negative in valence; rather, any emotion can be constructive or destructive depending upon whether the emotion improves one's situation or helps one to achieve a particular goal. Accordingly, Ekman classified six emotions as basic, including anger, fear, surprise, sadness, disgust, and happiness (Ekman & Friesen, 1971). Although he later theorized that other universal emotions may exist beyond these six (Ekman & Cordaro, 2011), the idea of six basic emotions are used in many studies, including those that investigate age differences in emotion perception (e.g., Gonçalves et al., 2018; Ruffman et al., 2008).

Although Ekman's work (e.g., Ekman & Cordaro, 2011; Ekman & Davidson, 1994; Ekman & Friesen, 1971) is often cited as the authority on emotion concepts, there are additional perspectives that contribute knowledge to our understanding of how emotion concepts develop and how they map onto our social experiences. In Russell (2003)'s view, emotions, moods, and other emotionally charged events fit into one framework. Central to this is core affect—or one's current, consciously accessible neurophysiological state—as a primitive, simple, and non-reflective feeling. Russell (2003) described core affect as points on a spatial plane formed by bipolar dimensions. The horizontal dimension of this plane captures valence, or pleasure–displeasure. It ranges from feeling extremely good to feeling extremely bad. The vertical dimension of the plane captures arousal, ranging from most energized to most enervated. Each dimension is continuous, and the two dimensions are orthogonal to each other (Barrett & Russell, 1999; Russell & Carroll, 1999). These two dimensions are derived from data obtained in tasks of self-reported feelings, including placing emotion words into eight categories—using labels like aroused, contented, depressed, distressed, excited, miserable, pleased, and sleepy—and placing the eight categories into a circular order, and sorting emotion words into multidimensional scaling. Data from different types of tasks confirm the same outcome, so Russell finally categorized emotions along a continuum with two dimensions: degree of arousal and degree of pleasantness. Across this space, various emotion concepts are spread evenly, suggesting that one's actual affective experience is more complex than it is represented in semantic structures.

Another differing perspective is offered by Elliot et al. (2013). They propose that emotion may be more than a phenomenological experience, but instead also involve fundamental components of motivation that will energize and direct organisms. Motivation generally involves two directions: approach motivation, which drives organisms toward a reward or incentive; and avoidance motivation, which drives organisms away from punishment or threat. Moreover, approach–avoidance motivation can intertwine with emotional valence as approach motivation is associated with positive feelings. In contrast, avoidance motivation is related to negative emotions except for anger, which can be linked to approach motivation.

Across perspectives, emotional valence seems to be a common theme (i.e., positive emotions vs. negative emotions). However, the divergent views of emotion build upon one another to identify other facets of experience and expression that are also critical to emotion. Together, valence, arousal, and approach–avoidance motivation reflect components of a sophisticated conceptualization of emotion and make the application of simple emotion labels to evocative stimuli more challenging for an observer.

Age Differences in Emotion Recognition

Past research shows that aging can disrupt one's ability to accurately identify emotions in the faces, posture, and words of others. It would not be surprising if older adults performed worse than younger adults in identifying all types of emotions because of presbyopia or aged-related cognitive decline. However, it would also make sense if older adults outperformed younger adults in all types of emotion recognition. Older adults generally have been interacting with others for more decades than younger adults, affording a greater opportunity to learn about emotion cues in everyday interactions and display superior performance in recognizing emotions. Yet age differences in emotion perception do not adhere to the same patterns across numerous studies (e.g., Gonçalves et al., 2018; Isaacowitz et al., 2007; Ruffman, Halberstadt, et al., 2009; Ruffman et al., 2008). Although some are consistent with age-related decline, some find age-related maturation of social processes.

Older adults typically have a lower accuracy when recognizing fear, sadness, and anger (Calder et al. 2003; Isaacowitz et al., 2007; McDowell et al., 1994; Orgeta & Phillips 2008; Ruffman et al., 2008; Wong et al., 2005), but they perform as well as or better than younger adults when recognizing disgust (Borod et al., 2004; Calder et al., 2003; Isaacowitz et al., 2007; Moreno et al., 1993; Phillips et al., 2002; Suzuki et al., 2007). Different patterns of age differences are observed for recognizing happy and surprise—some research demonstrates a smaller age deficit (Ruffman et al., 2008), and some find that older adults and younger adults have equivalent performance (McDowell et al., 1994; Murphy & Isaacowitz, 2010; Orgeta & Phillips, 2008; Phillips et al., 2002; Sullivan & Ruffman, 2004). Results in a meta-analysis (Ruffman et al., 2008) that included 17 datasets through 13 studies showed age differences in recognizing emotion faces. Older adults displayed worse performance than younger adults when evaluating anger, fear, and sadness (age effect .27–.34, $p \leq .01$). Although older adults also had difficulty in identifying happy and surprised faces, the magnitude of the age difference was much smaller (age effect .07–.08, $p \leq .05$). In addition, older adults outperformed younger adults at recognizing disgusted faces (age effect .11, $p \leq .07$). One dataset described in the meta-analysis found a medium effect size, negative age effect for recognizing disgusted faces (*r*

= .37), but 13 of 17 datasets showed a positive effect suggesting a strong possibility of better performance in recognizing disgust in older adulthood.

Similar results are also found in a summary of 14 previous studies on age differences in emotion recognition from facial emotions (Isaacowitz et al., 2007). Except for disgust, older adults were less accurate than younger adults at recognizing the negative emotions of anger, sadness, and, to some extent, fear. In their own study, Isaacowitz and colleagues asked both younger and older adults to observe photographs of emotional expressions of the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) and a set of neutral stimuli. The people who posed for the photographs included those ranging in age from young adulthood to late middle age. From seven possible labels, participants in the study chose the one that best described the emotion observed in each posed expression. They found that younger adults outperformed older adults when applying every label except disgust.

As mentioned above, some studies report an improvement in the recognition of disgust with age (e.g., Calder et al., 2003; Suzuki et al. 2007; Wong et al. 2005) with little evidence to disconfirm this association (e.g., Sullivan & Ruffman, 2004). In two experiments in Calder et al. (2003), researchers asked younger and older adult participants to identify which emotion was presented on photographs of six facial expressions (happiness, sadness, anger, fear, disgust and surprise), posed by each of 10 models (six females, four males). Older adults demonstrated better recognition of disgust than did younger adults but were poorer at recognizing fear and sadness in faces.

On the other hand, research by Ruffman and colleagues notes age-related deficits in disgust perception (e.g., Ruffman, Sullivan, et al., 2009; Ryan et al., 2010; Sullivan &

Ruffman, 2004). Using an emotion matching task, older adults had more difficulty matching emotional stimuli across modality (Sullivan & Ruffman, 2004). For this task, there were two sets of experiment materials. The first set included six non-verbal emotional sounds expressed by a male: a happy humming sound, sad sighs and groans, gasps and high-pitched tones of fear, angry snorts and "grr" sounds, light and high-pitched gasps of surprise, and "ughh" sounds of disgust. The second included passages read by an actress with each of the six basic emotional tones (happy, sad, fear, angry, surprise, and disgust). The participants were asked to match the soundtracks within each set to a choice of six emotion faces. Older adults had more difficulty than did younger adults when matching emotional sounds to angry, sad, and disgusted faces. This age-related decline in recognizing disgust has been shown elsewhere as well (Ruffman, Sullivan, et al., 2009; Ryan et al., 2010). In each of these studies, emotion perception was measured using either a faces-voices matching task or a bodies-voices matching task. Perhaps here, the integration that is needed across modality to be accurate taxes older adults' cognitive resources, increasing the odds of observing age-related decline.

In some emotion matching tasks, however, age differences in emotion perception are not as prevalent. For instance, researchers used emotion faces that were morphed by combining one emotional expression with a natural expression as the experimental stimuli, and asked participants to match the intensity of 20%, 40%, 60%, or 80% of the morphed emotion faces to the 100% intensity of the emotion faces in the same category (Mienaltowski et al., 2018). The facial stimuli included expressions of anger, disgust, fear, happiness, sadness, and no emotion (neutral). The results showed that older adults performed more poorly relative to younger adults when matching the 100% target stimulus to the 20% intensity standards for disgust and fear facial expressions. However, there were no age differences when performing the matching task at other degrees of intensity of emotion faces within the disgust and fear stimuli or when the emotion faces in other categories such as anger, happiness, and sadness were investigated.

Overall, the age deficit is apparent when recognizing fear, sadness, and anger in static facial expressions. For happy and surprised faces, older adults' performance is worse than or equal to younger adults' performance. Although older adults seem more sensitive to disgust cues in facial expressions than do younger adults, older adults' superiority was diminished when they were asked to match voices to faces or to bodily expressions. When it comes to matching emotion from facial expression to facial expression, age differences are only limited to low intensity expressions of disgust and fear. Does the diminished effect only emerge in specific modalities (e.g., in facial, vocal, or bodily stimuli)? Examining the evidence for age differences in emotion recognition in other modalities and across multiple simultaneously presented modalities helps us to better understand qualitative differences in how younger and older adults perceive emotion.

Emotion Recognition in Modalities Other Than Facial Stimuli

A meta-analysis that examined age differences in emotion recognition in different modalities, including faces, vocal and bodily stimuli, found that the pattern of age differences in emotion recognition varied across these modalities (Ruffman et al., 2008). As mentioned earlier, older adults were less accurate than younger adults when identifying fearful, sad, and angry faces but showed smaller deficits in identifying happy and surprised faces. However, this result was inconsistent with other findings from studies using vocal or bodily stimuli. For the voice modality, researchers analyzed five datasets in which participants were asked to label the emotion conveyed in auditory prosodies and auditory situations with one of the six basic emotions (anger, sadness, fear, happiness, surprise, and disgust). For instance, participants heard a nonverbal emotional sound (e.g., a happy humming sound) or a reading of the same passage conveying each of the six basic emotions through tone of voice and then pointed to an emotion word that matched the auditory expression (Ruffman. Sullivan, et al., 2009). Only one study asked participants to read a sentence describing a target person in an emotional situation and asked them to select the emotion from verbal labels of Ekman's six basic emotions plus neutral (Isaacowitz et al., 2007). The meta-analysis demonstrated that older adults were worse than younger adults in recognizing anger, sadness, and happiness, but were as successful as younger adults at recognizing fear, surprise, and disgust. This pattern held when omitting the Isaacowitz et al. (2007) study. Also, another study replicated this pattern of age differences in labeling vocal emotions (Ruffman, Halberstadt, et al., 2009).

For the body language modality, researchers (Ruffman et al., 2008) pooled the effect sizes together from three datasets of two experiments in the same paper (Ruffman, Sullivan, et al., 2009). In one experiment, participants were asked to label the emotion after they watched a 5-second (s) video clip of a male or female young adult who enacted one of five bodily expressions (e.g., fist shaking or stamping for anger, bending head or crouching for sadness, backing away or crouching for fear, turning away and hand-waving for disgust, raising arms or celebratory gestures for happiness). The young adults wore a suit that completely obscured the face and that had light points attached to 13 body joints. The authors manipulated whether participants saw the entire person in the suit (full-light task) or just the major movement points (point-light task). In another experiment, participants used one of six basic emotions to label each still photo that included one of four bodily/contextual expressions (e.g., anger: two men nose-to-nose, one gripping the other's collar; sadness: a woman with her head bent and in her hand; fear: a man with his hands in front of his face and pinned against the ground by another man; happiness: a woman clapping her hands), with faces digitally erased (Ruffman, Sullivan, et al., 2009). Across these studies, older adults were worse at identifying angry, sad, and fearful bodily expressions. There was no difference between younger and older adults for happiness, and no data were collected for surprise or disgust.

To sum up, older adults showed deficits in labeling happy, angry, and sad voice expressions and in labeling angry, fearful, and sad bodily expressions. This contrasts with older adults' deficits in recognizing facial emotion for all expressions except disgust when one considers age differences in emotion recognition in just the face modality.

Cross-Modal Emotion Recognition

As discussed earlier, age deficits in emotion recognition are not limited to unimodal stimuli (e.g., emotion perception in static face images). Instead, older adults have more difficulty matching emotional content across modalities (e.g., matching emotional vocal expressions to emotion faces or emotional bodies). Whereas researchers demonstrated that older adults performed significantly worse than did younger adults when matching angry, disgust, and sad vocal expressions to a corresponding emotion face (Sullivan & Ruffman, 2004), other studies showed significant elderly deficits in recognition of happiness, anger, and sadness (Ruffman, Halberstadt, et al., 2009; Ruffman, Sullivan, et al., 2009; Ryan et al., 2010). One of them indicated that older adults also performed worse than younger adults in matching fearful and disgusted voices to faces (Ruffman, Sullivan, et al., 2009). Although elderly deficits were only statistically significant for some of the emotions, younger adults appeared to outperform older adults on every one of the six basic-emotions in every study. In a meta-analysis (Ruffman et al., 2008), researchers pooled three datasets together and found that older adults were significantly worse at identifying all emotions. Moreover, another study showed elderly deficits in identifying all six basic emotions when matching voices to bodily emotional expressions (Ruffman, Halberstadt, et al., 2009).

An interesting pattern emerges when comparing the results from the studies focusing on unimodal with cross-modal emotion perception. First, older adults' performance was worse than younger adults in cross-modal matching tasks for all emotions, but these age deficits were only limited to the low-intensity facial expressions of disgust and fear in the unimodal task (i.e., faces–faces) when they did emerge. This finding suggests that older adults can identify emotion cues on faces. However, older adults have difficulty integrating the information of emotion cues from different sources. Second, the patterns of age differences are inconsistent across different emotions in emotion labeling tasks, suggesting that there is the complexity inherent to applying multiple labels during emotion perception tasks from trial to trial. That is, older adults have problems when labeling emotion stimuli from different modalities. Also, heterogeneity was shown for almost every emotion in a meta-analysis (Ruffman et al., 2008). In other words, there was much variance in the size of the differences between younger and older adults' performances. Researchers reported that all facial and vocal emotions were associated with significant heterogeneity, except surprised faces. Across four emotions that were included when studies required participants to label emotion depicted by body posture, heterogeneity was significant for sadness and happiness, but not anger or fear (i.e., perhaps differences are observed more consistently across studies). In faces-voices matching, however, heterogeneity between contributing effects were only shown on the emotion of disgust. As significant heterogeneity indicates that the effects contributing to the analysis differ substantively, the above evidence, when taken together, demonstrates that variance in effects among studies for each of the emotions are relatively large and ubiquitous across emotions for unimodal stimuli. On the other hand, the variance in the age effects for emotions perception are smaller among studies involving cross-modal stimuli (except for cross-modal comparisons including disgust).

The heterogeneity in effects for emotion category perception in unimodal focused studies but not in cross-modal focused studies emerges for at least two reasons. Of course, first, larger bodies of datasets may capture a higher likelihood of heterogeneity. Specifically, many previous studies have focused on age difference in labeling emotions (e.g., Calder et al., 2003; Isaacowitz et al., 2007; Lambrecht et al., 2012; Ryan et al., 2010; Sullivan, & Ruffman, 2004) whereas fewer studies investigate cross-modal emotion perception (e.g., Ryan et al., 2010; Ruffman, Sullivan, et al., 2009). This observation is quite salient when reviewing meta-analyses on this topic (Ruffman et al., 2008). Another possible reason for the heterogeneity that should not be ignored is the tendency for emotion perception studies to rely on verbal labels of emotion categories to gauge emotion perception. It is possible that differences between the results in studies involving unimodal stimuli and cross-modal stimuli are at least partly accounted for by age differences in how emotion labels are applied or in the evolution of emotion concepts across the lifespan.

Age Differences in Processing Emotion Concepts

Previous studies demonstrated that the change of one's perspective or mental state with age could affect information processing (Lynchard & Radvansky, 2012; Nelson & Russell, 2016; Widen & Russell, 2008). In one study (Lynchard & Radvansky, 2012), both younger and older adults took part in an orienting task. Participants in the orienting task were either to describe the experience that they were currently having or to describe what they would experience if they were in a condition that contrasts with their own age group (i.e., young become old and old become young). They then completed a lexical decision task (LDT) where they saw positive-emotion words, negative-emotion words, neutral words, or non-words on the computer screen, and they were required to identify whether stimuli presented were a valid word or a nonsense stimulus (i.e., non-word). The reaction time (RT) toward the stimuli was used to measure how easily activated these lexical stimuli were given the orienting task. Both young and old participants responded faster to the positive emotion words when they took the older adults' perspective, whereas they responded faster to the negative emotion words when they took the younger adults' perspective. Therefore, the researchers proposed that shifts in emotion orientation varied according to one's age-specific perspective on the world - young or old mindset (Lynchard & Radvansky, 2012). However, other evidence does not wholly support these findings.

Ferraro and colleagues found that the effect of induced emotional mood states on lexical processing similarly impacted lexical decision performance of both younger and older adults (Ferraro et al., 2003). Researchers randomly assigned younger and older adult participants to either a happy or sad mood induction condition. During the mood induction, participants listened to 8 minutes of classical music previously found to induce happy or sad moods. Then, participants completed an LDT, including happy, sad, and non-words. Results replicated previous studies with younger adults in that sad-induced individuals responded faster to sad words, and happy-induced individuals responded faster to happy words, but this outcome extended to older adults' LDT performance as well. Regardless of age, when an emotional state is activated within an individual, this state can also facilitate one's accessibility to mood-congruent lexical categories. Moreover, both age groups were able to activate either positively or negatively valenced emotion categories, suggesting some category structure maintenance with age.

In relation to emotion recognition tasks, consider what this means for the argument that older adults' deficits emerge due to faulty label application given the cognitive complexity associated with having to consider so many labels. In the study mentioned above, the specific emotions that were targeted for activation were activated via an induction procedure, and this activation facilitated categorization. In emotion recognition tasks, the participant shifts between labels from trial to trial. This introduces complexity in the labeling process, necessitating multiple categories to be simultaneously active. Emotions can be fundamentally classified, but their various components (e.g., valence, arousal, and motivation) reflect their more sophisticated nature. Applying simple emotion labels to evocative stimuli can be more challenging for an observer. The connection between the words that we use for emotion concepts and our personal experience of emotion emerges early on in life as we develop language. Understanding how children develop emotion concepts can help us to decipher the relationship between emotion recognition and labeling.

The Emergence of Emotion Concepts

Children's understanding of emotion concepts originates from the cause and consequence of the experience rather than from facial expressions alone (Widen, 2013; Widen et al., 2015). Previous research demonstrates the emergence of a story superiority effect in older children and adolescents relative to younger children (Widen et al., 2015). Story superiority refers to one's ability to interpret the emotional content of a story for a given discrete emotion relative to the emotion found in a static facial expression. In this study, participants aged 8–20 years were asked to identify emotions each after observing facial expressions (fear, disgust, pride, shame, or embarrassment) and after reading stories describing the cause and consequence of an emotion in each trial. For each story trial, participants were asked about the feelings of the protagonist and could respond with any word they wanted. Except for pride, participants were more accurate with their free labels for the emotions involved in stories than in facial expressions, and this advantage for the story increased with age. This finding suggests that adapting along with a context or a scenario is essential for the development of emotion concepts.

Emotion development begins with broad, simple categories (e.g., feels good, feels wrong) and then gradually expands by differentiating into more specific discrete emotion categories as children acquire more advanced language abilities (Nelson & Russell, 2016; Widen & Russell, 2008). Researchers examined how preschoolers (2–4 years old) encounter a new concept label by asking them to observe facial expressions one at time and providing them with novel descriptors for novel facial stimuli (Nelson & Russell, 2016).

For instance, the experimenter verbally provided the labels for each face, saying, “Is he/she happy, pax (one of the new concepts, another one was tolen), or sad?” and children selected a label to describe the poser’s feeling. Next, children freely labeled each expression that they saw previously. The majority of the children matched the novel expression with the novel label, suggesting that they succeeded by eliminating several less appropriate expressions. After only a few exposures to the novel label, nearly half of children freely labeled the novel expression with the novel label, pointing out that children recognized the new emotional expression, a puffed cheeks expression that was previously rated not more positive or more negative. This suggests that children’s preconceived expectations regarding expressions were minimal with respect to the novel expressions and were not constrained to existing emotion categories (Nelson & Russell, 2016). Additionally, this outcome points out that lexical labels do not reflect the entire nature of a given emotion, but, rather, helps us to have a peg by which to denote a concept.

Categorical Perception of Facial Expressions of Emotion and Lexical Categories

Facial expressions of emotion likely developed through evolutionary means given their importance to social interactions and also likely developed concurrent with language. Although language for emotion helps us to organize categories, it is not required to perceived distinct categories. In Sauter et al. (2011)’s study, two groups of participants were recruited; one group consisted of native speakers of Yucatec Maya and the other consisted of German speakers. As a language, Yucatec Maya lacks a clear lexical definition for anger. Thus, only German speakers were expected to display lexical distinctions between disgust and anger (two of Ekman’s basic emotions) in a free naming task. On the other hand, despite lacking the appropriate verbal descriptor for anger, Sauter et al.

(2011) found that the Yucatac Maya speaking group was still able to perceptually distinguish between anger and disgust. Participants completed a delayed match-to-sample task in which they were presented with a target image on the computer screen that was followed by a pair of facial images of emotion. One of these images was the target but the other was a perceptual neighbor consisting of a morphed combination of the original image and more of the competing emotion. The foil stimuli depicted emotion morphed on continuum between two of the three emotions included in the study (sadness, disgust, and anger) in different proportions (e.g., 80% disgusted/20% sad and 60% disgusted/40% sad). Participants were asked to identify the target. Sauter et al. (2011) found that speakers of Yucatec Maya were able to categorically distinguish anger from disgust just as well as the German speakers within the perceptual judgment task despite not offering anger-specific labels. This result is consistent with the possibility that emotion concepts, although connected to their labels, emerge in a manner that does not automatically require lexical categories.

Although verbal labels are not necessary to perceive emotion, labels do change how we perceive emotions. When provided with an emotion word, one might use this label to aid prediction when evaluating the emotion cues in non-lexical stimuli. That is, labels can provide an internal context that helps one to more quickly process emotion cues or which might bias one toward a particular conclusion about the emotion expressed. Fugate et al. (2018) recruited college students and designed experiments that presented an emotion word before an emotion-mixed, morphed face set to investigate the role that labels play in influencing the saliency of emotion cues in faces. Each morphed face set contained a target face and two distractor faces. The target face was created from two emotional expressions (e.g., scowling and relaxed) mixed in roughly equal proportions, and distractor faces were more and less intense versions of these emotional expressions (e.g., more scowling-less relaxed or less scowling-more relaxed). Before presenting the target face, participants observed an emotion word consistent with the meaning carried by one of the emotional expressions morphed within the target face (e.g., “anger”). A mask followed the target face. Then, participants saw the target face and two distractor faces and chose which one was the target. In another experiment, participants indicated in separate trials whether each of the three faces (the target face and two distractor faces) was the target face seen earlier in the trial. Across experiments, Fugate et al. (2018) essentially used a match-to-sample task post-prime and stimulus presentation to understand how the emotion words biased the participants’ memory for the emotional content in the initial face stimulus. On average, instead of choosing the correct target face, participants selected the distractor face depicting a more intense expression of the emotion represented by the emotion word prime, suggesting that emotion word primes affected how the target stimulus was encoded. In other words, the prime word may focus the participant on those emotion cues that are salient and congruent with the prime word itself.

Current Study

Although age differences in emotion perception are commonly observed, consistency in findings across studies is lacking. Additionally, across methods and modalities, age differences can disappear or be exacerbated. Consider that, despite age deficits in emotion recognition in emotion labeling tasks, older adults performed as well as younger adults did when matching faces to faces based on their emotion cues. Absent the presence of labels, older adults appear to be able to perceive emotional signals on faces to the same degree that younger adults do. Although this finding is appealing because it supports age-related maintenance of emotion perception, it is limited by other studies demonstrating that older adults clearly have difficulty integrating emotion cues from different modalities to successfully match what they see to what they hear or read. In sum, data in this area of social cognition and aging reflect inconsistency. One question that remains to be investigated is the role that providing participants with labels during emotion recognition tasks plays in the prevalence of age effects. Do these labels constrain what participants see, hear, or read? Are these labels the labels that people actually use when characterizing the emotion in their social partners? It seems like the nature of emotion is more complex than would be suggested via the existence of orthogonal lexical structures for discrete emotions. As mentioned earlier, younger adults do not need lexical categories for an emotion to perceptually categorize perceived facial emotion cues. However, emotion words do influence how college students perceive emotions on faces. It is interesting to ask if emotion labels influence older adults' emotion perception in a similar way to how they influenced younger adults' emotion perception. The current study used a match-to-sample paradigm preceded with emotion words as was used in Fugate et al. (2018) to investigate this question.

Specifically, the current study sought to understand the role that emotion labels play in how younger and older adults perceive emotions in subsequent, immediately presented faces. This study extended the work of Fugate et al. (2018) by focusing on the confusable, arousing negative emotions of anger, disgust, and fear, and by also assessing older adults' match-to-sample performance. Participants observed a target stimulus that was a roughly equal mix of two facial expressions (e.g., scowling/grossed-out, scowling/flinching, or grossed-out/flinching). Each expression depicted a certain emotion focus: scowling faces (angry faces), grossed-out faces (disgust faces), and flinching faces (fearful faces). The target stimulus was preceded by a word prime that was a non-emotion, neutral word or an emotion word. When the word was an emotion prime, it was a word reflecting one of the two emotions in the target stimulus. Afterwards, a mask appeared and then was followed by two comparison stimuli. One of these stimuli was the original target stimulus and the other stimulus was a distractor that was another two-emotion mixed face similar to the target stimulus but dominated by one emotion in the pairing (e.g., 70% scowling/30% grossed -out, or 30% scowling/70% grossed-out). Consequently, on some trials the emotion prime was more consistent with the distractor in the memory task (e.g., "anger" is more consistent with a 70% scowling/30% grossed-out face than with the initial stimulus—the 50% scowling/50% grossed-out face). In other trials, the emotion prime was more consistent with the target choice (e.g., "anger" is more consistent with the initial stimulus—the 50% scowling/50% grossed-out face—than with 30% scowling/70% grossed-out face).

The prediction was that participants would choose the one stimulus that matches the original target stimulus (the objectively correct stimulus). However, if participants behaved in a manner consistent with those tested in Fugate et al. (2018), participants would choose the one member of the comparison pair that more intensely displayed the emotion captured by the prime word. This would lead to a performance decrement when the incorrect foil presented with the correct stimulus was more consistent with the emotion prime word, and this would lead to a performance enhancement when the incorrect foil presented with the correct stimulus was less consistent with the emotion prime word.

Given the changes in the design of this experiment (i.e., now a true match-to-sample task rather than a modified one) relative to Fugate et al. (2018), this study investigated a number of hypotheses. Keep in mind that should one have difficulty perceiving emotion on the target or comparison stimuli, memory performance should be close to evenly divided for that individual between the standards. Also, keep in mind that in order for the emotion word to bias emotion perception within the match-to-sample task, participants must be able to discern emotion cues in the presented facial expressions that are consistent with the emotion that the emotion word carries. Consistent with Fugate et al. (2018)'s finding, younger participants were expected to bias their memory toward the delayed match-to-sample stimuli consistent with the emotion word. Specifically, given two emotions—Emotion 1 and Emotion 2—when the emotion word was more consistent with Emotion 1, then the memory task response should favor the stimulus where Emotion 1 was dominant. To be more concrete, for scowling/grossed-out trials, the word prime "anger" should lead younger participants to choose (a) the more scowling stimulus incorrectly when paired with the ambiguous scowling/grossed-out stimulus, and (b) the ambiguous scowling/grossed-out stimulus correctly when paired with the more grossed-out stimulus.

The current study investigated whether this crossover interaction pattern differed as a function of the emotions combined in the images. Specifically, whether the emotion words disrupt delayed match-to-sample performance similarly when considering each of the three affective face sets: scowling/grossed-out, scowling/flinching, and scowling/flinching. Prior research suggests that angry faces and disgusted faces are more confusable than the other pairings because they share a number of facial emotion cues (Aviezer et al., 2011). Consequently, the interaction between the dominant emotional expressions and the type of word prime was expected to be larger for scowling/grossed-out trials than for scowling/flinching or grossed-out/flinching, as the latter pairings are more easily discriminated by both younger and older adults (Mienaltowski et al., 2013). No predictions were made concerning possible differences in how the emotion words impact the scowling/flinching versus grossed-out/flinching trials.

The current study also extended prior efforts to understand how emotion words influence emotion perception by including an older adult sample. As discussed earlier, older adults often struggle with emotion recognition relative to younger adults. Consequently, with respect to the delayed match-to-sample task, although older adults could show a similar pattern of findings as younger adults, it was expected that their memory performance would be inferior (i.e., lower performance for neutral prime trials). Additionally, past research suggests that older adults may rely more on any available context—the prime word—when encoding the initial face stimulus older adults, which would exacerbate memory biases within the match-to-sample task (Noh & Isaacowitz, 2013). Specifically, older adults could benefit more from prime-consistent words in choosing the correct ambiguous emotion stimulus when this target stimulus was presented with a foil in which the dominant emotion depicted in the expression was opposite to the prime word. Additionally, older adults' memory performance could be disrupted to a great extent than younger adults' memory performance when the emotion prime word added context that drove them to choose the incorrect foil simply because it expressed a higher intensity of the prime-consistent emotion.

Method

Participants

A total of 74 younger adults (YA) were recruited from Western Kentucky University (WKU)'s Study Board and Amazon Mechanical Turk (Mturk), and a total of 48 older adults (OA) were recruited from Mturk. Participants who took part in this study via Study Board received five credits (1 credit/15 minute), and participants from Mechanical Turk earned at least $12.50 (~$10/hour) for completing the study, provided they followed instructions and passed attention checks. All participants were screened to determine if they had more than 28 trials in the emotion face match-to-sample task (10% of 288 total trials) with reaction RT less than 200 ms or longer than the maximum time (YA: 8000 ms; OA: 12000 ms). Fast responding and excessive time-outs signal inattentive participation, so only participants who passed this screen were included in the study. One younger adult was excluded because their age exceeded that typical for a younger adult age group (i.e., 40 years old). Also, 10 older adults were excluded from analyses because they provided similar, suspicious information in open-ended comments during the task on the same sign-up date and because their performance on several cognitive tests was different from other older adults (see Table 1). All participants were native English speakers. The study protocols were reviewed and approved by the WKU Institutional Review Board (IRB#

20-189; see Appendix A, B, and C for complete proofs), and participants provided informed consent before they took part in the experiment. The demographic and cognitive characteristics of the younger and older adult samples are shown in Table 2.

Stimuli and Materials

Participants completed several tasks within this study. Amongst these were a delayed match-to-sample task using mixed emotion facial stimuli, a test of verbal ability (Advanced Vocabulary), a test of perceptual speed (Number Comparison), a visual spatial short-term memory task (the Corsi task), a depression inventory (Center for Epidemiological Studies Depression scale), a mood inventory (Brief Mood Introspection Scale), and a demographics form. These tasks were programmed and executed in an internet-based form using PsyToolkit (Stoet, 2010, 2017). More information about these tasks is provided below.

Emotion Face Match-To-Sample Task

In Fugate et al. (2018), participants were presented with mixed-emotion face stimuli, preceded by an emotion word. The emotion word was the categorical descriptor for the one of the two emotions found in the mixed-emotion face stimulus on each trial. After a brief presentation of a mask, participants were asked to choose one of three comparison face stimuli as a match for the mixed-emotion initial target stimulus. The three comparison stimuli included the original stimulus, a distractor stimulus more strongly depicting the emotion reflected by the prime word, and a distractor stimulus more strongly depicting the other emotion in the mixed-emotion target. In another experiment in Fugate et al. (2018), participants provided a response for each of the three stimuli one at a time after the mask was presented instead of choosing one stimulus from the three available (one target and two distractors). The current study adapted this paradigm by using a true match-to-sample task. That is, participants saw an ambiguous, twofold-emotion mixed target, and after masking, selected one of two stimuli—the target or a distractor—to match the original target stimulus. Again, word primes were presented before the onset of the target stimulus to influence the emotion perceived by the participants. Below is information about the task itself and the stimuli selected for the current study.

Matching Task. Age differences in facial emotion perception are common when participants are asked to evaluate the emotional content of confusable, arousing negative facial expressions, like anger, disgust, and fear. Within the matching task, these three emotions were paired with one another across trials. Specifically, anger and disgust, anger and fear, and disgust and fear were pitted against one another within the match-to-sample task. Facial images of a target expressing each emotion pair—for instance, scowling anger and grossed-out disgust—were mixed together (a) in relatively equal proportions such that neither emotion was more salient than the other, and (b) in unequal proportions such that each emotion contributed incrementally more to the resulting morphed face. During each trial, a fixation cross was presented for 1,000 ms, and then participants were presented with either an emotion word or a neutral word for 500 ms. This word prime was followed by a target face stimulus for 1,000 ms. The target face was a stimulus that was generally observed as consisting of equal proportions of each emotion. So, from trial to trial, this target face consisted of emotion cues of anger (scowling) + disgust (grossed-out), anger (scowling) + fear (flinching), or disgust (grossed-out) + fear (flinching). Also, from trial to trial, participants either first observed a neutral word or an emotion word corresponding to one of the two emotions found within the mixed emotion target stimulus. Neutral prime words reflected an abstract concept instead of an emotion (duty, trend, and opinion were used in the experimental trials; aura, usage, and thought were used in the practice trails). These words were selected from the 3,188 words in the Affective Norms for English Words (ANEW; Bradley, & Lang, 2017), and met the following two criteria: (a) arousal and valence were rated mid-range at 4.5 to 6.5 on a 9-point scale, and (b) the word length is compatible with fear, anger, and disgust (i.e., the length of four, five, and seven letters). After the target face stimulus, a noise mask appeared on the display for 1,000 ms to eliminate any afterimage of the target. Next, the target face and a distractor face appeared on the display simultaneously and the participant had an unlimited amount of time to indicate which of the two comparison standards was the original target stimulus.

The critical manipulation here was the two stimuli that were presented contained different proportions of two facial emotion cues. First, the objectively correct stimulus was identical to the target image and consisted of proportionally the same amount of each emotional expression. Second, the incorrect stimulus also consisted of both emotions found in the target image but contained incrementally more of one emotional expression. For instance, if the target stimulus consisted of 50% angry expression (e.g., scowling) and 50% disgusted expression (e.g., grossed-out), the foil in the memory test of the match-to-sample task contained 70% scowling/30% grossed-out or 30% scowling/70% grossed-out. Again, the objectively correct response in the task was for the participant to choose the 50% scowling/50% grossed-out stimulus, but, if Fugate et al. (2018)'s findings extended here, participants who were primed with "anger" should have been more inclined to choose (a) the 70% scowling/30% grossed-out stimulus versus the 50% scowling/50% grossed-out stimulus, and (b) the 50% scowling/50% grossed-out stimulus versus the 30% scowling/70% grossed-out stimulus. For the sake of clarity, trials in which the distractor's depicted emotional expressions were more consistent with the emotion word prime are called "distractor dominant" and trials in which the target face stimulus's depicted emotional expressions were more consistent with the emotion word prime are called "target dominant". Also, the stimuli in which the dominant emotional expression depicts the emotion prime word are called Emotion 1 (e.g., 70%/30%) and stimuli in which the dominant emotional expression is inconsistent with the emotion prime word are called Emotion 2 (e.g., 30%/70%). If an emotion prime word influences memory performance, participants should choose the objectively correct stimulus over the Emotion 2 stimulus on target dominant trials but should also choose the Emotion 1 stimulus over the objectively correct stimulus at test on distractor dominant trials.

The matching task included 3 (Emotion mix: scowling/grossed-out, scowling/flinching, and grossed-out/flinching) × 2 (Word prime: emotion vs. control) × 2 (Prime reference: target dominant vs. distractor dominant) conditions with a total of 288 trials. For half of these trials, an emotion word prime was used (144 trials), and for the other half a neutral prime was used (144 trials). For the emotion word prime trials, half used words for each of the emotions found in the target image—24 "Anger" and 24 "Disgust" for scowling/grossed-out combination, 24 "Anger" and 24 "Fear" for the scowling/flinching combination, and 24 "Disgust" and 24 "Fear" for the grossed-out/flinching combination. Within each of these 24-trial pools, all utilized the most ambiguous morphed face as the objectively correct stimulus (i.e., the target stimulus). However, for half of the trials (12 trials), the biased outcome was expected to lead to selecting the objectively correct stimulus (e.g., 50%/50% over 30%/70%; the target dominant condition). For the other half (12 trials), the biased outcome was expected to lead to the incorrect Emotion 1 stimulus (e.g., 70%/30% over 50%/50%; the distractor dominant condition). For each condition and each target, the objectively correct response appeared on the left side of the display half of the time and on the right side of the display the other half of the time. Stimuli were presented at the center of the computer screen. The screen's resolution was set to 1280 (width) × 1024 (height) pixels by PsyToolkit.

Stimuli for Matching Task. Facial stimuli were adapted from the IASLab Face Set.[1] The face set that was used in the matching task includes three male targets and three female targets expressing three combinations of confusable, arousing negative emotions – including scowling faces (angry faces), grossed-out faces (disgust faces), and flinching faces (fearful faces). Following Fugate at al. (2018), two different facial emotion depictions from each identity were morphed together to create three affective face sets (scowling-grossed-out, scowling-flinching, and grossed-out-flinching) each with seven morphs (with the intensity of 100%–0%. 80%–20%, 70%–30%, 50%–50%, 30%–70%, 20%–80%, and 0%–100%). This process was performed on 10 possible targets from the IASLab Face Set (10 targets × three sets × five morphs = 150 stimuli). A pilot study was then conducted using PsyToolkit that asked participants to view and classify each morph by choosing one of two emotion labels (Emotion Identification Task). Responses to each label were calculated as a percentage across age groups and morph sets and plotted to present the average emotion perceptions produced by the stimuli (see Figure 1). The crossover of the two psychophysical curves (i.e., the black solid line and the dash line) indicates the point where participants perceived the most ambiguous emotion. Accordingly, the stimulus closest to the crossover point on the graph was identified as the target or ambiguous face. Then, the two distractor faces were one step greater and one step less than the target face (e.g., target face: 50% scowling/50% flinching; distractor face one: 70% scowling/30% flinching; distractor face two: 30% scowling/70% flinching; see Figure 1a) in psychophysical space of emotion.

The resulting face set was not always 50%/50% (target), 30/70%, and 70/30% (distractors). The stimuli were identified according to the psychophysical curves, and separate psychophysical curves were established via pilot testing for each age group. Figure 1b illustrated the psychophysical space of younger adult participants when perceiving scowling/grossed-out faces as angry or disgusted. First, the 30% scowling/70% grossed-out morph is closest to the crossover on the graph, indicating it is perceptually ambiguous compared to the other six morphs in the set. Second, the 50% scowling/50% grossed-out stimulus is one step greater (scowling) than the 30% scowling/70% grossed-out target face, but the 20% scowling/80% grossed-out face is not less (scowling) than the target face. The gap between the two psychophysical curves over the 20% scowling/80% grossed-out stimulus is smaller than the gap over the target, suggesting more considerable ambiguity in the 20% scowling/80% grossed-out stimulus. The 0% scowling/100% grossed-out stimulus is psychophysically one step less (scowling) than the 30% scowling/70% grossed-out target face. As a result, the target face is 30% scowling/70% grossed-out, the distractor face one is 0% scowling/100% grossed-out, and distractor face two is 50% scowling/50% grossed-out. In total, there were three faces per target, so a total of 54 faces (six targets × three sets × three morphs) were included in the main study (see Table 3). Abrosoft FantaMorph software was used to create the facial stimuli (see Figure 2 for samples). The facial stimuli were always presented as 400 (width) × 600 (height) pixel images in the experiment.

The Outcome of the Pilot Study. Twenty-six younger adults (14 females) between the age of 18–24 years (M = 19.27; SD = 1.25) were recruited from WKU's Study Board and received academic credits for participating. Thirty older adults (16 females) between the age of 60–72 years (M = 64.43; SD = 3.38) were recruited from Amazon Mturk and were paid a small stipend. All participants completed the Emotion Identification Task on the internet. Their responses were used to identify the target stimuli and distractor stimuli used in the matching task. However, there were some stimuli without a reasonable outcome for identifying a target stimulus (see Figure 3). For the rest, face sets were identified in each emotion-mix condition, and these sets included the three best female face examples and three best male examples available for use in the study's matching task. Face sets were selected by applying the following criteria to psychophysical curves for each target: (a) the target is relatively equally likely to be labeled as either emotion, and (b) the distractors should be as equally discriminable from the target as possible. For this latter point, discriminability differences captured by the difference in height observed in the psychophysical curves of the stimuli should be equivalent or as equivalent as possible. The outcome of the pilot study can be seen in Table 3 by target (or actor).

Individual Difference Measures

Additional measures were administered to younger and older adults to compare the two samples on measures of cognitive functioning, mood, and depression psychopathology. These measures included the Advanced Vocabulary Test and Number Comparison Test from the Kit of Factor Referenced Cognitive Tests (Ekstrom et al., 1976), the Corsi task (Kessels et al., 2000; Stoet, 2010, 2017), and the Center for Epidemiological Studies Depression scale (CES-D; Radloff, 1977). In addition, the Brief Mood Introspection Scale (BMIS; Mayer & Gaschke, 1988) was also administered to obtain a comprehensive assessment of each participant's current mood state.

Advanced Vocabulary Test. This test was adapted from the original paper-based version (Cronbach's α = .68; Ekstrom et al., 1976) for use on PsyToolkit (Stoet, 2010, 2017) for remote data collection. This test examines participants' verbal ability. The original version contains 36 items over two pages, with 18 items on each page. This internet-based version only included the first half of one form of the test in order to minimize fatigue during the experimental session. Participants read the instructions and pressed the space bar to start the test when they were ready. There was only one item presented at a time with five foil word options. Participants identified which one foil had the same meaning or nearly the same meaning to the target word by pressing a key to indicate their answer. Participants were told that their score will be the number marked correct minus a fraction of the number marked incorrect. They were also discouraged from guessing. To make it possible to avoid guessing, an extra response option was included so that participants could indicate: "I do not know, and I do not want to guess." Participants had up to 4 minutes to respond to 18 items. The test could end sooner if the participant did not require the full 4 minutes.

Number Comparison Test. This test was adapted from the original paper-based version (Cronbach's α = .82; Ekstrom et al., 1976) for use with PsyToolkit (Stoet, 2010, 2017) and remote data collection. This test assesses perceptual speed. The original assessment included two pages of items (or 96 items), and this version was reduced by half in order to minimize participant fatigue. The Number Comparison task used in this study included 48 pairs of number strings ranging in size from three digits to thirteen digits. One at a time, a pair of number strings was presented on the right side and the left side of the fixation cross on the computer screen. Participants were asked to compare each pair and decide whether the number strings were identical or differed by one digit. Participants pressed the "I" key if the numbers were identical, and they pressed the "D" key if the numbers were different. After participants read the instructions, they completed a set of eight practice trials with feedback. They were then provided 90 seconds to complete as many comparisons as possible from the list of 48 trials.

Corsi Task. This task is a complex visuospatial short-term memory task (Kessels et al., 2000). In the current study, we adapted the online version provided in PsyToolkit's experiment library by adding practice trials before the task starts (Stoet, 2010, 2017). In the task, nine purple blocks appear scattered on the screen. The blocks are lit up in yellow in a span sequence, and an auditory cue ("Go") is used to indicate when the participant should respond. Participants were instructed to use their mouse to click the blocks in the same sequence that they were lit up when they hear the cue word. The task includes two to seven experimental blocks with three trials in each. Each block reflects an incremental increase in visuospatial short-term memory set size. In other words, the task starts with only two blocks lit up on the first trial, and the sequences become incrementally longer when participants provide a correct response. If the participant provides a correct response, they are given a second attempt. A second error within a given set size ends the task. The highest number of correct blocks recalled in sequence (two to seven) reflects the Corsi span achieved by the participant. Before the task, all participants received a block of practice trials with two blocks lit up. Older-adult participants were required to perform successfully on two of three 2-block trials before beginning the actual task to ensure that they understood the instruction.

Center for Epidemiological Studies Depression Inventory (CES-D). This self-report scale was designed to measure the current level of depressive symptomatology in the general population and can be used with adults of all ages (Radloff, 1977). The inventory consists of 20 items, including items for depressed affect (e.g., “I felt depressed”), somatic and hindered activity (e.g., “I was bothered by things that usually don’t bother me”), and interpersonal factors (e.g., “People were unfriendly”). Plus, four items are worded in a positive direction (e.g., “I felt hopeful about the future”) to break participants’ response tendencies and assess the absence of participants’ positive affect. Participants were asked to indicate how often they have felt the way described in the item during the past week. The inventory was entered into survey format in PsyToolkit, and participants responded by using the mouse to click their rating choice. Participants did not have a time limit, and they were advised to go with their first natural response. The score on each item ranges from 0 (*less than one day*) to 3 (*5-7 days*). Total scores can range from 0 to 60, with higher scores indicating more depressive symptoms (Cronbach's α = .90 in YA sample; Cronbach's α = .94 in OA sample).

Brief Mood Introspection Scale (BMIS). This open-source mood scale measures an individual's current mood using two pairs of factor dimensions, including an unrotated, basic mood structure labeled as pleasant–unpleasant and arousal–calm dimensions, and its varimax-rotated factor solution is called positive–tired and negative–relaxed dimensions (Mayer & Gaschke, 1988). The BMIS was programmed into PsyToolkit as individual survey items. Participants observed 16 adjectives (happy, lively, loving, caring, calm, content, active, peppy, jittery, nervous, grouchy, fed up, tired, drowsy, gloomy, and sad) one at a time and indicated how well each adjective described their present mood. Responses were on a 4-point scale anchored by definitely do not feel, do not feel, slightly feel, and definitely feel. Responses are coded for the four scales: Pleasant–Unpleasant (Cronbach's α = .89 in YA sample; Cronbach's α = .92 in OA sample), Arousal–Calm (Cronbach's α = .37 in YA sample; Cronbach's α = .47 in OA sample), Positive–Tired (Cronbach's α = .84 in YA sample; Cronbach's α = .87 in OA sample), and Negative–Relaxed (Cronbach's α = .72 in YA sample; Cronbach's α = .85 in OA sample). At the end of the questionnaire, a final scale was presented that asked participants to place a slider along a range of -10 (very unpleasant) to 10 (very pleasant). Participants used their mouse to move the slider to indicate their overall mood. The current study focuses on participants' ratings of their overall mood, the Pleasant–Unpleasant scale, and the Arousal–Calm scale. Researchers suggested that the Pleasant–Unpleasant scale yields higher validity, cautioning that the Arousal–Calm scale may have low reliability (Cavallaro et al., 2019).

Procedure

Participants were recruited via WKU's Study Board and Amazon Mturk and were directed to the experiment's page programmed within PsyToolkit. Participants from Amazon Mturk entered their Mturk ID, age, and native language to screen for eligibility. All qualified participants were presented with an informed consent document to agree to before they started the experiment. The first task of the session was the match-to-sample task. Participants first carried out eight practice trials with feedback on accuracy to familiarize themselves with the task and the response keys. The stimuli used in the practice trials were those from morphed face sets that were not selected for the main task given the results of the aforementioned pilot study. Apart from the stimuli and the use of feedback, the practice trials were identical to the experimental trials. Participants carried on to the experimental trials after completing the practice.

On each trial, participants were presented with a fixation cross for 1,000 ms followed by a prime word (an emotion word or a control word) for 500 ms. An ambiguous target face was then displayed on the screen for 1,000 ms, followed by an afterimage-removing mask for 1,000 ms. Immediately after the mask disappeared, the target face and a distractor face were presented simultaneously, counterbalanced by the display side (on the screen's left or right side). Participants had sufficient time (YA: 8000 ms; OA: 12000 ms) to choose which one image was identical to the target. The next trial started after the decision was made. A total of 288 experimental trials were presented randomly in six sessions with an unlimited-time break between the sessions. At the beginning of each session, a short instruction was applied to remind participants about the task (e.g., which key they should press to respond). The instruction did not include any information to direct participants' attention to the primes, but it asked participants to focus on the screen at all times.

After completing the match-to-sample task, participants received the BMIS, the Advanced Vocabulary Test, the Number Comparison Test, the CBT, the CES-D scale, and the demographics. At the end of the experiment, participants were debriefed and automatically directed to Google's search engine's home page. The whole procedure of the experiment took approximately 57 minutes.

Results

Delayed Match-to-sample Task

Overall, participants answered correctly 59.64% of the time (OA: 62.47%, YA: 58.00% over all conditions; OA: 62.46%, YA: 57.94% in the control condition; see Table 4). Given that this proportion exceeds chance, it appears that participants could perceptually distinguish the facial expressions and were not merely guessing. For each condition, discrimination performance, or *d'* values, and response bias, or *c* values, were calculated from the hit rate and the false alarm rate using signal detection theory.

According to SDT (Macmillan & Creelman, 1990; Macmillan & Creelman, 2005; Stanislaw, & Todorov, 1999), the signal and noise distributions generally involve four possible outcomes—(a) hit: a "yes" response when the signal is present (e.g., selecting the target at test from the standards), (b) miss: a "no" response when the signal is present (e.g., failing to select the target at test from the standards), (c) false alarm: responding "yes" even though the signal is absent (e.g., choosing the distractor at test from the standards), and (d) correct rejection: responding "no" when the signal is absent (e.g., does not choose the distractor at test from the standards). The current study included a 2-alternative forced-choice decision at the test. Consequently, one alternative, defined by the display's side, was specified as the target side to be designated as a hit (or miss). The other side was specified as the second alternative and was used to characterize false alarms (or correct rejections). For instance, if participants chose the left alternative when the target image appeared on the left, they hit the target. If they chose the right alternative, then they missed the target. However, if participants selected the right alternative when the target image appeared right, this was a correct rejection. Should they choose the left alternative, this was a false alarm. Then, the following formulas were used to calculate the hit rate (*H*) and the false alarm rate (*F*):

$$H = \text{hit}/(\text{hit} + \text{miss}) \quad (1)$$

$$F = \text{false alarm}/(\text{false alarm} + \text{correct rejection}) \quad (2)$$

This process for calculating *H* and *F* can be counter-intuitive but is necessary in order to determine if participants' favor (i.e., show a bias) one alternative (e.g., the one on the left). Ultimately, *d'* was calculated by converting *H* and *F* into *z*-scores, then applying the formula:

$$d' = z(H) - z(F) \quad (3)$$

This sensitivity index, *d'*, is used to measure the standardized difference between the mean of the signal distribution and the mean of the noise distribution (Fugate et al., 2018; Macmillan & Creelman, 1990; Macmillan & Creelman, 2005; Stanislaw, & Todorov, 1999). Higher values for *d'* reflect one's superior ability to correctly locate the target independent of the word prime. The same z-scores were used to calculate a response bias as well, or *c* (for criterion), where $c = -[z(H) + z(F)]/2$. Positive values of *c* reflect a tendency to indicate that the target is the left alternative, whereas negative values reflect a tendency to indicate that the target is the right alternative. The most extreme *c* value is +2.33 or -2.33 when hit rates and false alarm rates are both as low as .01 or as high as .99, respectively. However, consistent performance in responding results in the false alarms equal to miss rates, $z(F) = z(1 - H) = -z(H)$, and *c* equals zero.

Note that, within this task, if participants cannot discern prime-consistent cues in the facial expressions that are presented on the target face, then their memory performance will be close to evenly divided between response keys. Ultimately, this would lead to *d'* and *c* values near to zero. If participants can perceive the prime-consistent cues in the facial expressions, then their *d'* and *c* values can be influenced by the word primes if they use these semantic codes to organize their memory of the target. Should this happen, then, when primed with an emotion word, participants should be more likely to choose the alternative that was more intense. Fugate et al. (2018) provided little guidance here as they used three alternatives as a test, each presented one at a time, and thus performance was subject to memory decay and interference as this technique introduces more error in their measurement of participant memory.

d' Analyses

Participants' *d'* values were submitted to a 2 (Participant age group: younger, older) × 3 (Emotion mix: scowling/grossed-out, scowling/flinching, and grossed-out/flinching) × 3 (Prime reference: target-dominant, distractor dominant, and control) mixed model ANOVA in which age group was a between-subjects factor, while emotion mix and prime reference were within-subject factors. The participants' average *d'* values are depicted in Figure 4. A *d'* value of zero indicates chance performance, and increasing *d'* values reflect participants' higher sensitivity to the emotion cues on the target face (Macmillan & Creelman, 2005). The analysis revealed significant main effects for age group and emotion mix: $F(1, 102) = 11.64$, $p < .001$; $\eta^2_p = 0.10$, and $F(2, 204) = 38.42$, $p < .001$; $\eta^2_p = 0.27$, respectively. Older adults ($M = 1.12$, $SE = 0.08$) outperformed younger adults ($M = 0.71$, $SE = 0.08$), but both age groups did not display high discrimination accuracy in this emotion face match-to-sample task (see Figure 3). *Post hoc* comparisons using the Tukey HSD test on the emotion mix revealed that participants performed differently in discriminating the scowling/grossed-out morphed face ($M = 1.01$, $SE = 0.07$), the scowling/flinching morphed face ($M = 0.53$, $SE = 0.07$), and the grossed-out/flinching morphed face ($M = 1.21$, $SE = 0.07$). However, the main effect of prime reference was not significant, $F(2, 204) = 0.18$, $p = .84$; $\eta^2_p = 0.002$, and there were no 2-way or 3-way interactions that reached statistical significance.

c Analyses

The c value averaged across all participants, emotion mix conditions, and prime reference conditions was 0.04 ($SD = 0.36$; ranged from -1.405–1.405), suggesting that participants did not show a biased response tendency to either side of the display. The *c* values were, then, submitted to a 2 (Participant age group: younger, older) × 3 (Emotion mix: scowling/grossed-out, scowling/flinching, and grossed-out/flinching) × 3 (Prime reference: target-dominant, distractor dominant, and control) mixed model ANOVA in which age group was a between-subjects factor, while emotion mix and prime reference were within-subject factors (see Table 5). The analysis did not reveal a significant difference between younger and older adults' response biases, $F(1, 102) = 0.24$, $p = .623$; $\eta^2_p =$

0.002. However, the main effect of emotion mix was significant, $F(2, 204) = 3.30$, $p = .039$; $\eta^2_p = 0.03$. Additional *post hoc* comparisons using the Tukey HSD test on the emotion mix reveal a difference between scowling/flinching ($M = 0.08$, $SE = 0.03$), and grossed-out/flinching condition ($M = 0.02$, $SE = 0.03$), but not between scowling/grossed-out ($M = 0.04$, $SE = 0.03$) and scowling/flinching, or scowling/grossed-out and grossed-out/flinching. This result suggested that participants' specific response tendencies slightly favored the left alternative for the scowling/flinching pair, which is the pairing that generally led to weaker memory performance as indexed by *d'* values.

Reaction Times

Participants' RT values were submitted to a 2 (Participant age group: younger, older) × 3 (Emotion mix: scowling/grossed-out, scowling/flinching, and grossed-out/flinching) × 3 (Prime reference: target-dominant, distractor dominant, and control) mixed model ANOVA in which age group was a between-subjects factor, while emotion mix and prime reference were within-subject factors (see Table 6). The analysis only revealed significant main effects for emotion mix, $F(2, 204) = 4.99$, $p = .008$; $\eta^2_p = 0.05$, where participants significantly responded faster on grossed-out/flinching (DF) face trials ($M = 1297$ ms, $SE = 40$ ms) than on scowling/grossed-out face trials ($M = 1329$ ms, $SE = 40$ ms) and on scowling/flinching face trials ($M = 1336$ ms, $SE = 40$ ms).

Exploratory Outcomes for Individual Difference Measures

Data was also collected for a number of individual difference measures. The younger and older adult samples were compared across these measures using independent sample t-tests (see Table 2). The result demonstrated that the typically observed differences between younger and older adult samples emerged in this study, except no difference in Corsi span emerged between the two age groups. Younger adults outperformed older adults on processing speed measures (i.e., number comparison test), whereas older adults showed superior vocabulary ability, fewer depressive symptoms, and more positive/less negative mood states relative to younger adults.

The correlation model included younger-adult and older-adult participants' accuracy in different conditions of the match-to-sample (MTS) task—such as the target dominant (TD) condition, the distractor dominant (DD) condition, and the control condition—to allow for the exploration of relationships between performance within these specific conditions and the individual difference measures (see Table 7). In the control condition, younger adults' MTS performance correlated with the Advanced Vocabulary Test (r = 0.38, p = .002), with the Number Comparison Test (r = 0.39, p = .001), and with the Corsi Test (r = 0.26, p = .035), indicated that better cognitive abilities may support younger adults as they memorize the target emotion faces in the match-to-sample task. When there was an emotion word prime that was consistent with the meaning carried by the target face, the factors that positively correlated with the MTS performance included the score of the BMIS's arousal-calm mood scale (r = 0.30, p = .015), the number of correct trials in the Advanced Vocabulary Test (r = 0.40, p < .001), and the number of correct trials in the Number Comparison Test (r = 0.25, p = .040). These factors were also positively correlated with younger adults' MTS performance in the DD condition (the Number Comparison Test: r = 0.46, p < .001; the score of BMIS's arousal-calm mood scale: r = 0.33, p = .006), except the number of correct trials in the Advanced Vocabulary Test (r = 0.21, p = .091). These findings suggest that higher arousal and better perceptual speed may boost younger adults' ability to correctly choose the target face whenever the emotion word prime was either consistent or inconsistent with the meaning carried by the target face. Better vocabulary ability may have supported match-to-sample memory as well but only in the TD condition but not the DD condition.

For older adults, the number of correct trials in the Number Comparison Test was positively correlated with the MTS performance in the control condition ($r = 0.39$, $p = .016$), suggesting that better perceptual speed may support memory to correctly choose the target emotion face. However, this advantage does not extend to the word prime conditions (TD: $r = 0.27$, $p = .097$; DD: $r = 0.29$, $p = .073$). The fisher's z test also showed that older adults' vocabulary ability contributed little to their MTS performance in the TD condition whereas younger adults' vocabulary ability was in part related.

Discussion

The aim of this study was to investigate whether words serve as a context to impact the age effect in emotion perception for facial stimuli. Past research demonstrates that older adults often have more difficulty using verbal labels of emotion to categorize emotion face stimuli relative to younger adults. Age differences are particularly pronounced for emotions like anger and fear, but seem to be less prevalent for disgust. However, when emotion recognition tasks limit the possible emotion choices of participants to two (e.g., anger versus disgust) or require participants to simply match stimuli based on emotion without the use of labels, age differences all but disappear for facial stimuli except when the stimuli depict low-intensity expressions. This evidence implies that emotion labels play a role in driving possible age differences in emotion perception.

Factors Influenced Perceptual Memory of Complicated Emotion Faces

This study extended the work of Fugate et al. (2018) by using a match-to-sample paradigm preceded with emotion words as primes but focusing on the emotions of anger, disgust, and fear and investigating older adults in addition to younger adults. The current study showed that younger and older adults' memories for the emotion faces were perceptually driven and not meaningfully influenced by the meaning of word primes. Both age groups relied on facial cues rather than the conceptual information found in the primes to match and determine which emotion face they had recently seen in the phase of each trial introducing the target stimulus. In Fugate et al. (2018)'s study, the emotion words affected participants' perceptual judgments of a target face when morphed faces were comprised of combinations of high/low arousal emotions or low/low arousal emotions (e.g., scowling/relaxing or frowning/relaxing). However, the three affective face sets—scowling/grossed-out, scowling/flinching, and scowling/flinching—used in this study were arousing negative emotions and were more difficult to distinguish. With the shifting contrast of one emotion pairing to another from trial to trial, the facial cues were far more informative for the participants than the words. This argues that the perceptual priming effect found in other studies utilizing the same techniques may not be robust and certainly may not be differentially observed as a function of age group. The Fugate et al. (2018) study only observed the priming effect for a highly arousing negative emotion, anger, in combination with low arousal emotions. Perhaps under these conditions the priming word can draw more attention to the distracting emotion cues, exaggerating the participants' representation of the highly arousing negative emotion. Again, in the current study, all emotion combinations were highly arousing negative emotions, diluting the influence of lexical primes on perceptual cues.

This study also explored the relationship between cognitive abilities and the performance of the match-to-sample task. In the younger-adult group, participants who presented better performance in the control condition of the match-to-sample task demonstrated higher abilities of vocabulary, perceptual speed, and visuospatial short-term memory. This finding is consistent with the characteristic of the match-to-sample task which involves lexical and facial stimuli and requires participants' short-term memory to recall the target emotion face. In the condition involving target-dominant emotion words, the correlation between the match-to-sample performance and vocabulary was significantly stronger than the same relationship with the control condition. Participants with a broader vocabulary may have a more sophisticated, rich semantic network which could facilitate using words in a heuristic fashion (i.e., primes presented operating to focus attention on relevant details of stimuli). When participants who had better vocabulary were presented with an emotion word prime, they were easily prompted of the concept of that emotion and tended to make the correct choice.

On the other hand, in the condition involving distractor-dominant emotion words, the correlation between the match-to-sample performance and perceptual speed was significantly stronger than the same relationship with performance in the control condition of the match to sample task. Perceptual speed was examined by the Number Comparison task in which participants looked at two strings of numbers and then decided whether the numbers were identical. Although participants might be able to quickly identify shorter strings (e.g., three-digit strings), they were more likely to use conjunction search for the majority of the task because of similar features shared among the numbers. That is, the speed with which participants rejected the identical number (distractors) affected how quickly they could move on to the next number until they found a different number or until the end of the search. Better perceptual speed benefits the match-to-sample performance in the distractor dominant condition. Originally, the expectation was that participants would be primed by the emotion word that was consistent with the meaning of the distractor face, adding false information about the emotion concept into their perceptual memory of the target face and resulting in the tendency to choose distractor faces and a worse match-to-sample performance. Participants with better perceptual speed are better able to reject distracting information, maintaining a more accurate perceptual memory and consequently demonstrate a superior match-to-sample performance.

Older adults who demonstrated more accurate memory performance in the control condition of the match-to-sample task also displayed higher perceptual speed. For older adults' success in the delayed match-to sample task, fluid cognitive abilities appear to matter more than other cognitive abilities. Note however that this study included only a limited range of individual difference measures to assess participant cognitive functioning. In the other two conditions (target dominant and distractor dominant), no relationship was observed between match-to-sample performance and cognitive abilities for older adults. The differential pattern of relationships observed between younger and older adults suggests that further studies are needed to understand what role specific cognitive resources may play in supporting emotion face memory.

Limitations

In addition to the aforementioned limitation about the breadth of cognitive measures used in this study, other limitations are important to discuss. The word priming effect could have been desensitized through the trials (Dijksterhuis & Smith, 2002). While participants had been continuously exposed to the arousing, negative words such as anger, disgust, and fear, they may end up experiencing these words as only moderately negative or they may even ignore reading the prime. The priming effect might have been lessened as the trials in the task progressed because of affective habituation, resulting in non-significant word priming effects overall. To identify whether participants in this study experienced affective habituation, their data can be split into temporal epochs and further analyzed. However, given that all trials are presented at random throughout the task, this analysis was not possible. Another limitation of the primes used in the match-to-sample task is their word frequency. The current study used the ANEW word stimulus norms (Bradley & Lang, 2017) to match the control words against the emotion words to ensure that they have similar arousal level and word length. However, the ANEW word stimulus norms did not include word frequency. Previous studies have demonstrated that low-frequency words usually take longer to process than high-frequency words (Brysbaert et al., 2018; Monsell et al.,1989). One possible consequence of this limitation is that memory errors could be inflated early on in the match-to-sample task. Further limitations exist with respect to the facial stimuli as well. Specifically, facial stimuli were selected based on ordinal differences between the target and distractors. A specific threshold for the distractors' categorical certainty relative to the target was not defined and applied from one actor to the next. Consequently, participants may have found trials with some actors easier than trials with others within the same experimental conditions.

This study was impacted by the COVID-19 pandemic which necessitated changes in the participant recruitment strategies. Such changes likely introduced some confounding factors. While the younger-adult sample was recruited from WKU, the older-adult sample was recruited via the Mturk instead of from the community around WKU as originally planned. Older adults recruited from the internet may not represent the average older-adult population, perhaps influencing them to outperform younger adults on the match-to-sample task and several individual difference tasks. Given monetary incentives associated with participation and quality control in adherence to instructions implemented through the Mturk platform, older adults' motivated performance seems assured. On the other hand, younger-adult participants' motivation may have been affected by participating in the study outside of a laboratory setting and for course credit instead of monetary compensation. Differences between our samples' motivation can serve as an alternate explanation for the correlation between the match-to-sample performance and several cognition tasks in the younger-adult group. If motivation is a variable, then the distracted group would have poorer performance in all the tasks. On the other hand, the motivated group would perform better in the majority of tasks that required higher attention, such as the match-to-sample task and the cognition tasks. If this is the case, then the correlations between the match-to-sample performance and several cognition tasks were confounded by participants' motivation.

Suggestions for follow up studies could aim to investigate the following questions. First, does the type of emotion affect the priming effect of emotion words on the two age groups? When participants were presented with high arousal, complex mix morphed faces in comparison with the morphed faces used in Fugate et al. (2018)'s study (i.e., low/high arousal combinations), performance appears to be driven by perceptual cues and the previously observed priming effect disappeared. The finding is in line with Sauter et al. (2011)'s study in which participants also observed more complicated morphed faces, raising the possibility that the recognition of several salient emotion cues existing on a face may not be easily affected by top-down processes introduced by prime words. Second, will a sustained language context develop if the same word primes are constantly shown? In the current study, the total experimental trials were presented randomly in a single session while participants were exposed to different emotion words and emotion cues from trial to trial. This might attenuate the top-down process, resulting in the disappearance of the priming effect. Future studies should be conducted to further examine this, perhaps blocking trials of each face morph pair combination in separate blocks. Third, do cognitive abilities influence younger adults' match-to-sample performance or are the relationships confounded by participants' motivation? To understand the relationships between the match-to-sample performance and cognitive abilities in the younger-adult group, future studies should also recruit younger adults from the internet to control for possible extra variables. In the case of this study, this was not possible given financial limitations associated with collecting data from an additional sample of younger adults.

Conclusion

In summary, the current study indicated that short-term memory for an arousing, negative emotion face appears to be strongly driven by perceptual cues. This might suggest that the bottom-up processing plays a stronger role when stimuli are perceptually complex, as accurate performance will rely more on discerning the most salient perceptual cues from trial to trial than on use of extraneous information not contributing to the memory judgment. Age differences were limited, but the correlation analysis demonstrated that fluid cognitive abilities may matter more to older adults' performance than to younger adults' performance in the memory task. The findings of this study demonstrate that that are many additional questions to address to fully understand how exactly lexical stimuli might influence face perception and memory performance in a delayed match-to-sample task.

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Footnotes

[1] This study acknowledges the use of the face set from the Interdisciplinary Affective Science Laboratory. Note that the development of the Interdisciplinary Affective Science Laboratory (IASLab) Face Set was supported by the National Institutes of Health Director's Pioneer Award (DP1OD003312) to Lisa Feldman Barrett. More information is available online at www.affective-science.org.

Table 1

Comparison of Dropped and Kept Older Adult Participants

Measure	Dropped OA (n = 10)		Kept OA (n = 38)			
	M	*SD*	*M*	*SD*	*p*	Cohen's *d*
Age	65.00	0.00	65.16	4.27		
Education	10.00	0.00	6.97	2.56		
MTS Accuracy	53.54	3.22	62.47	7.04	<.001[a]	-0.632
BMIS Overall Mood	8.60	1.26	4.76	4.14	<.001[a]	1.255
BMIS PUM	39.00	7.29	29.42	9.49	.005	1.052
BMIS ACM	24.70	3.92	35.05	4.01	<.001	-2.592
CESD	32.80	8.52	7.32	9.64	<.001	2.702
VC Number of Correct Trials	5.30	1.83	11.47	2.88	<.001	-2.279
VC Number of Completed Trials	18.00	0.00	17.89	0.65	.613	0.181
VC Mean RT (ms)	2382	1668	6712	2582	<.001	-1.782
NC Number of Correct Trials	17.40	4.55	16.00	2.50	.198	0.464
NC Number of Completed Trials	20.60	11.40	18.32	3.00	.268[a]	0.514
NC Mean RT (ms)	2677	1063	2982	573	.401[a]	-0.357
Corsi Span	5.60	0.84	5.32	1.14	.467	0.261

Note. Education level around 6 indicates some college, and 10 indicates a master's degree; MTS = match-to-sample task; BMIS = Brief Mood Introspection Scale (Mayer & Gaschke, 1988); PUM = pleasant-unpleasant mood scale; ACM = arousal-calm mood scale; Center for Epidemiological Studies Depression Inventory (Radloff, 1977); VC = Advanced Vocabulary Test (Ekstrom et al., 1976); Mean RT = average reaction time over all trials (ms); NC = Number Comparison Test (Ekstrom et al., 1976).

[a] Levene's test is significant ($p < .05$); therefore, this analysis is using Welch's *t*.

Table 2

Participant Characteristics

Measure	YA (n = 66; 38 female)		OA (n = 38; 22 female)			
	M	*SD*	*M*	*SD*	*p*	Cohen's *d*
Age	21.21	3.54	65.16	4.27		
Education	6.05	1.79	6.97	2.56		
MTS Accuracy	58.00	6.72	62.47	7.04	.002	-0.654
BMIS Overall Mood	2.68	4.88	4.76	4.14	.029	-0.450
BMIS PUM	37.83	8.65	29.42	9.49	<.001	0.938
BMIS ACM	32.62	3.79	35.05	4.01	.003	-0.628
CESD	19.11	10.95	7.32	9.64	<.001[a]	1.143
VC Number of Correct Trials	7.06	2.44	11.47	2.88	<.001	-1.693
VC Number of Completed Trials	17.61	1.55	17.89	0.65	.188[a]	-0.243
VC Mean RT (ms)	7324	5455	6712	2582	.517	0.132
NC Number of Correct Trials	17.15	3.24	16.00	2.50	.046[a]	0.398
NC Number of Completed Trials	20.58	5.08	18.32	3.00	.014	0.509
NC Mean RT (ms)	2644	727	2982	573	.016	-0.501
Corsi Span	5.39	1.16	5.32	1.14	.740	0.068

Note. Education level between 5-7 indicates some college; MTS = match-to-sample task; BMIS = Brief Mood Introspection Scale (Mayer & Gaschke, 1988); PUM = pleasant-unpleasant mood scale; ACM = arousal-calm mood scale; Center for Epidemiological Studies Depression Inventory (Radloff, 1977); VC = Advanced Vocabulary Test (Ekstrom et al., 1976); Mean RT = average reaction time over all trials (ms); NC = Number Comparison Test (Ekstrom et al., 1976).

[a] Levene's test is significant ($p < .05$); therefore, this analysis is using Welch's t.

Table 3

The Intensity (%) of Stimuli Facial Depictions Identified by the Pilot Outcome

Facial depictions of the stimuli	Face set[a]	YA			OA		
		D1	Target	D2	D1	Target	D2
Scowling/ grossed-out	F1	**50/50**	**70/30**	**80/20**	**30/70**	**50/50**	**70/30**
	F2	**50/50**	**70/30**	**80/20**	**30/70**	**50/50**	**70/30**
	F3	20/80	70/30	80/20	**30/70**	**50/50**	**70/30**
	F4		n/a			n/a	
	F5	**30/70**	**50/50**	**70/30**		n/a	
	M1	**30/70**	**50/50**	**70/30**		n/a	
	M2	**0/100**	**30/70**	**50/50**	**20/80**	**30/70**	**50/50**
	M3		n/a		**20/80**	**70/30**	**70/30**
	M4	**30/70**	**50/50**	**70/30**	**30/70**	**50/50**	**70/30**
	M5		n/a			n/a	
Scowling/ flinching	F1	30/70	50/50	70/30		n/a	
	F2	**50/50**	**70/30**	**80/20**	**50/50**	**70/30**	**80/20**
	F3	**50/50**	**70/30**	**80/20**	**30/70**	**50/50**	**70/30**
	F4	50/50	70/30	80/20	50/50	70/30	80/20
	F5	**30/70**	**50/50**	**70/30**	**20/80**	**30/70**	**50/50**
	M1	30/70	50/50	70/30	**50/50**	**70/30**	**80/20**
	M2	**0/100**	**30/70**	**50/50**	0/100	20/80	50/50
	M3		n/a		**70/30**	**80/20**	**100/0**
	M4	**50/50**	**70/30**	**80/20**	**50/50**	**70/30**	**80/20**
	M5	**0/100**	**20/80**	**30/70**		n/a	
Grossed-out/ flinching	F1	**20/80**	**30/70**	**50/50**	**30/70**	**50/50**	**70/30**
	F2	**20/80**	**30/70**	**50/50**	20/80	30/70	50/50
	F3	**30/70**	**50/50**	**70/30**	**30/70**	**50/50**	**70/30**
	F4	0/100	20/80	50/50	**30/70**	**50/50**	**70/30**
	F5	20/80	30/70	50/50		n/a	
	M1		n/a		**30/70**	**50/50**	**70/30**
	M2	**20/80**	**30/70**	**50/50**	0/100	30/70	50/50
	M3	**30/70**	**50/50**	**70/30**	**30/70**	**50/50**	**70/30**
	M4	30/70	50/50	70/30	30/70	50/50	70/30
	M5	**20/80**	**30/70**	**50/50**	**20/80**	**30/70**	**50/50**

Note. Stimuli that were used in the matching task are in boldface; D1= distractor 1; D2 = distractor 2; n/a = not applicable because there is no reasonable outcome.

[a]Labels in the Face set column identify the morph performed by the same actor; F = female; M = male.

Table 4

Correct Proportions (%) Broken Down by Conditions

Conditions		YA		OA	
		Mean	*SD*	*Mean*	*SD*
Over all conditions		58.00	6.72	62.47	7.04
Emotion Mix	Scowling/grossed-out	58.98	7.66	63.57	8.82
	Scowling/flinching	54.17	6.31	55.73	6.47
	Grossed-out/flinching	58.85	10.61	65.63	9.63
Prime Reference	Target Dominant	57.64	8.72	62.50	7.41
	Distractor Dominant	58.33	8.92	61.11	7.95
	Control	57.94	7.01	62.46	7.92

Table 5

Estimated Means in the c Analyses by Age Groups

Emotion Mix	Prime Reference	YA *M*	OA *M*
Scowling/grossed-out	TD	0.05	0.00
	DD	0.10	0.05
	Control	0.05	0.00
Scowling/flinching	TD	0.04	0.15
	DD	0.12	0.10
	Control	0.05	0.02
Grossed-out/flinching	TD	0.01	0.00
	DD	0.05	0.00
	Control	0.06	-0.02

Note. Assumes equal variances among cells. Standard errors in younger adults (YA) group is 0.05, and in older adults (OA) group is also 0.05. TD = target dominant condition; DD = distractor dominant condition; Control = control condition.

Table 6

Estimated Means in the Analyses of Reaction Time by Age Groups

Emotion Mix	Prime Reference	YA *M* (ms)	OA *M* (ms)
Scowling/grossed-out	TD	1316	1337
	DD	1288	1373
	Control	1292	1344
Scowling/flinching	TD	1295	1386
	DD	1327	1372
	Control	1295	1353
Grossed-out/flinching	TD	1275	1344
	DD	1263	1334
	Control	1279	1337

Note. Assumes equal variances among cells. Standard errors in younger adults (YA) group is 71 ms, and in older adults (OA) group is also 69 ms. TD = target dominant condition; DD = distractor dominant condition; Control = control condition.

Table 7

Correlations Between the Variables for the MTS Task and Individual Difference Measures in Younger- and Older- Adult Groups

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1.	MTS Accuracy	—	0.81***	0.77***	0.93***	0.86***	0.84***	0.95***	-0.09	0.05	0.01	0.24	0.04	0.37*	0.19
2.	MTS Accuracy–AD	0.83***	—	0.36*	0.62***	0.64***	0.69***	0.80***	-0.08	0.07	0.12	0.26	0.08	0.14	-0.04
3.	MTS Accuracy–AF	0.68***	0.38**	—	0.69***	0.69***	0.68***	0.70***	-0.08	0.06	0.10	0.07	-0.10	0.42**	0.22
4.	MTS Accuracy–DF	0.90***	0.63***	0.43***	—	0.84***	0.75***	0.88***	-0.06	-0.002	-0.16	0.25	0.08	0.41*	0.31
5.	MTS Accuracy–TD	0.84***	0.68***	0.60***	0.74***	—	0.65***	0.74***	0.05	-0.10	-0.10	0.13	0.01	0.27	0.18
6.	MTS Accuracy–DD	0.79***	0.59***	0.54***	0.77***	0.58***	—	0.69***	-0.04	0.03	0.06	0.23	-0.11	0.29	0.14
7.	MTS Accuracy–Control	0.90***	0.80***	0.59***	0.77***	0.61***	0.53***	—	-0.16	0.12	0.03	0.26	0.12	0.39*	0.18
8.	BMIS Overall Mood	-0.19	-0.22	0.03	-0.21	-0.20	-0.15	-0.14	—	-0.75***	-0.32	-0.40*	0.18	-0.06	-0.09
9.	BMIS PUM	0.11	0.14	0.004	0.11	0.08	0.16	0.07	-0.75***	—	0.40*	0.59***	0.05	-0.05	-0.06
10.	BMIS ACM	0.27*	0.22	0.26*	0.20	0.30*	0.33**	0.13	-0.23	0.17	—	0.05	0.03	-0.01	-0.08
11.	CESD	0.07	0.17	-0.04	0.02	0.04	0.08	0.05	-0.41***	0.57***	-0.06	—	0.15	-0.06	0.03
12.	VC Correct	0.40***	0.46***[a]	0.14	0.34**	0.40***[a]	0.21	0.38**	-0.22	0.06	0.22	0.06	—	0.04	0.19
13.	NC Correct	0.44***	0.34**	0.27*	0.43***	0.25*	0.46***	0.39**	0.04	0.01	0.11	-0.04	-0.01	—	0.35*
14.	Corsi Span	0.14	0.03	0.26*	0.09	0.02	-0.01	0.26*	0.04	-0.06	-0.21	0.02	0.23	0.06	—

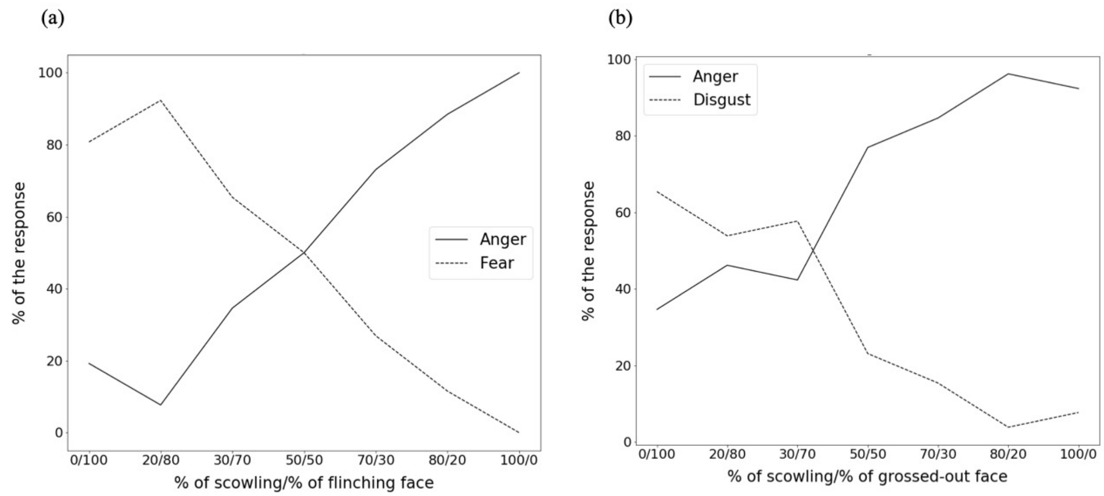
Note. Older adults are above and younger adults below the diagonal. MTS = match-to-sample task; AD = scowling/grossed-out condition; AF = scowling/flinching condition; DF = grossed-out/flinching condition; TD = target dominant condition; DD = distractor dominant condition; Control = control condition; BMIS = Brief Mood Introspection Scale (Mayer & Gaschke, 1988); PUM = pleasant-unpleasant mood scale; ACM = arousal-calm mood scale; PTM = positive-tired mood scale; NRM = negative-relaxed mood scale; Center for Epidemiological Studies Depression Inventory (Radloff, 1977); VC Correct = number of correct trials in the Advanced Vocabulary Test (Ekstromet al., 1976); NC = number of correct trials in the Number Comparison Test (Ekstrom et al., 1976).

[a] Differs from older adults' correlations at $p < 0.05$.

* $p < .05$, ** $p < .01$, *** $p < .001$

Figure 1

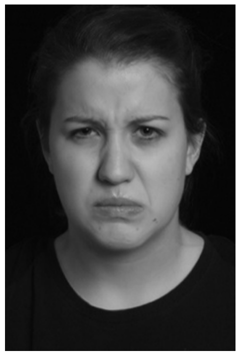
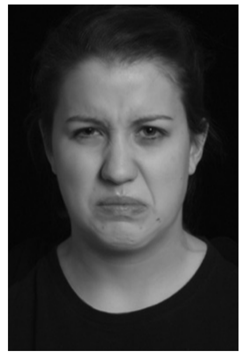
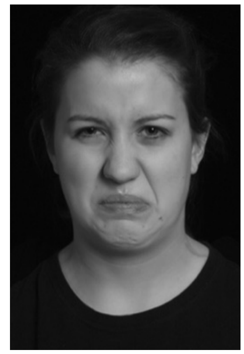
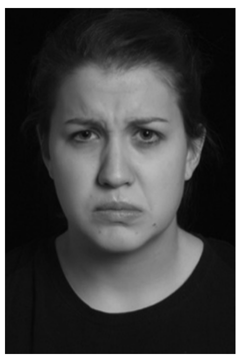
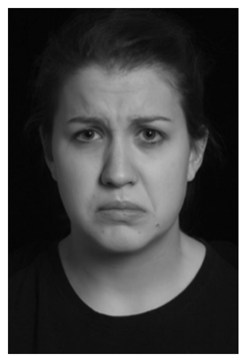
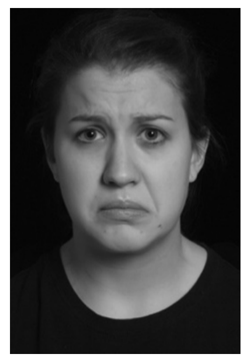
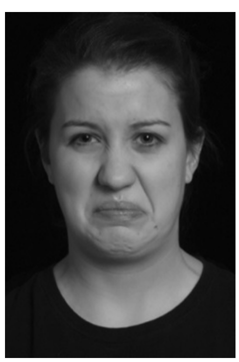
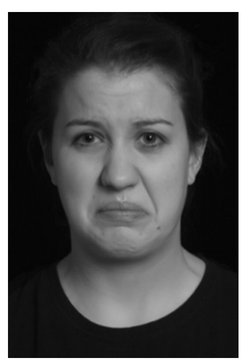
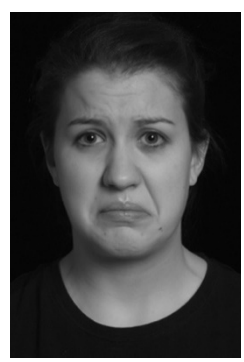
Examples of Psychophysical Curves Pooled Across Pilot Responses



Note. The figure presented two examples of psychophysical curves pooled across pilot responses in each age group in either a scowling/flinching or a scowling/grossed-out face set: (a) the crossover happened for a particular facial stimulus, simplifying stimulus selection to the nearest two images to the crossover stimulus, also known as the target, and (b) the crossover happened in the psychophysical space between two facial stimuli, complicating stimulus selection because there is no crossover stimulus. The solid curve represents the responses of choosing "Anger" label in each panel, and the dotted curve represents the responses of choosing the "Fear" label in the scowling/flinching trial and the "Disgust" label in the scowling/grossed-out trial.

Figure 2

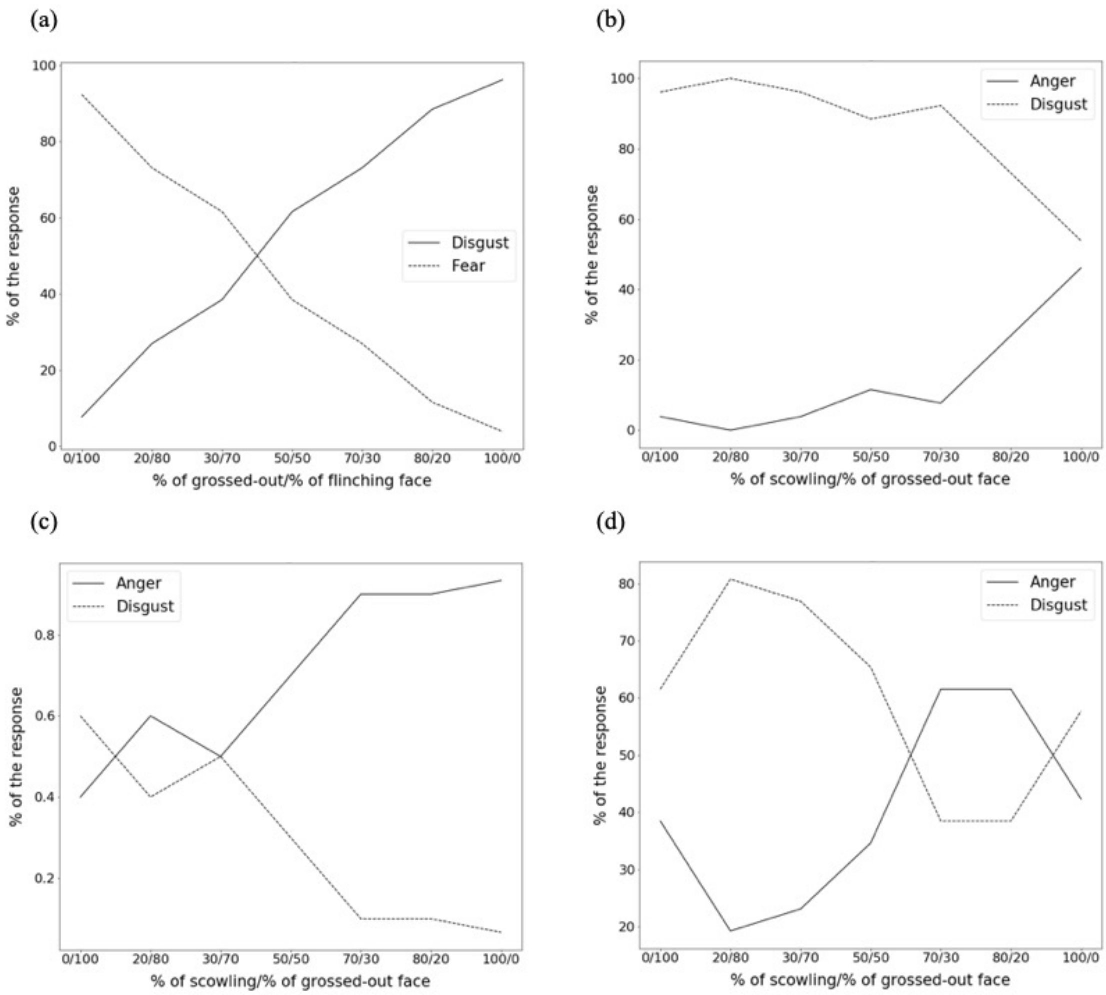
Face Set Morph Samples When 50%/50% Morphs Are Identified as the Target

Emotions of the Facial Depictions	Emotion 1	Ambiguous Targets	Emotion 2
Anger and Disgust	 70% scowling and 30% grossed-out	 50% scowling and 50% grossed-out	 30% scowling and 70% grossed out
Anger and Fear	 70% scowling and 30% flinching	 50% scowling and 50% flinching	 30% scowling and 70% flinching
Disgust and Fear	 70% grossed-out and 30% flinching	 50% grossed-out and 50% flinching	 30% grossed-out and 70% flinching

Note. The target depicted disgust and fear include in the experiment, but the other two sets not.

Figure 3

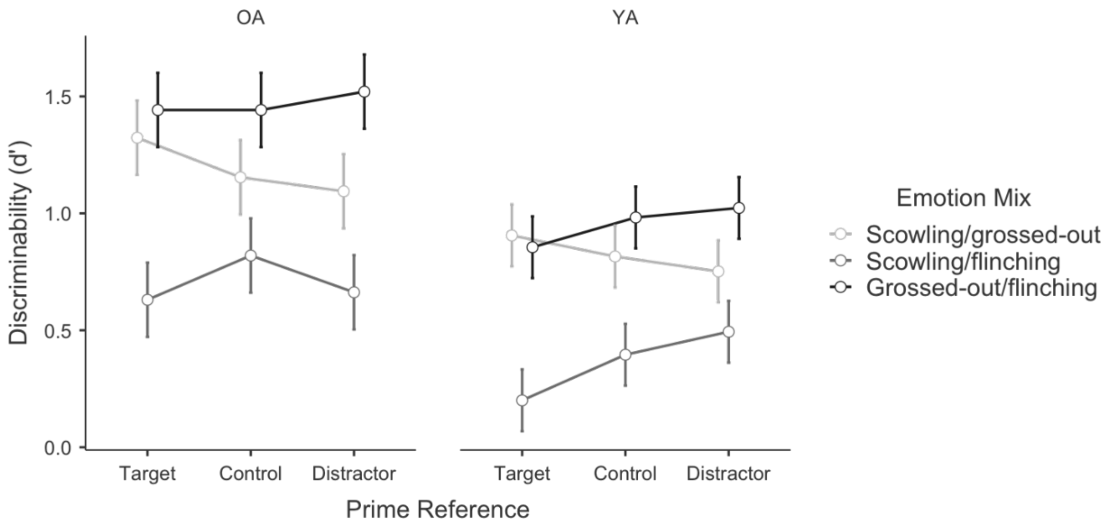
Examples of Psychophysical Curves Drawn No Reasonable Outcome



Note. Psychophysical curves drawn based on pilot participants' responses in the Emotion Identification Task that rendered no reasonable outcome: (a) the crossover happened between two facial stimuli, (b) the crossover did not happen, (c) the two psychophysical lines merged, suggesting an unusual pattern in emotion identification, and (d) two crossovers happened.

Figure 4

The Marginal Means Plot of d' Analyses



Note. The mean d' value (indicated by the circle) for target dominant, control, and distractor dominant condition for each age group in each emotion mix condition. Error bars denote standard errors.

Appendix A

Informed Consent of the Pilot Study

INSTITUTIONAL REVIEW BOARD WKU APPROVED

INFORMED CONSENT DOCUMENT

Project Title: Emotion Identification Task
Investigator: Dr. Andrew Mienaltowski, Psychological Sciences, WKU, (270) 681-0270

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your consent to participate in this project.

You must be 18 years old or older to participate in this research study.

Participants complete this study in the lab using paper-and-pencil measures and computer software. This form includes information on the purpose of the project, the procedures used, and the potential benefits and possible risks of participation. A basic explanation of the project is written below. Please read this explanation. If you then decide to participate, there will be a place to sign on the next page.

1. **Nature and Purpose of the Project:** This study investigates your perception of emotion in images of faces. Your role as a participant is to respond to the questions in order to tell us what you see.

2. **Explanation of Procedures:** In this study, you will complete a demographics form and some brief measures of cognitive ability and emotionality. You will also complete a task where you observe a number of facial images and are asked to indicate which emotion is conveyed by each. You will be provided labels to choose from for each image. The study should take no more than 90 minutes to complete.

3. **Discomfort and Risks:** There are no known or anticipated risks to the subject for participating. Participants are free to end an experimental session at any time, in the event that they experience fatigue or boredom.

4. **Benefits:** There are no direct benefits for participating. Your participation will help us understand how people perceive emotion in facial expressions. Individuals who take part in this study via Study Board will earn 6 Study Board credits (1 credit per 15 minutes). Individuals from the community will be compensated $15.

5. **Confidentiality:** During this study, you will be asked for some personal information (age, gender, etc.). This information will be confidential and will only be used by the experimenter. The data that is collected about you will be kept private. To protect your privacy, your records will be kept under a code number rather than by name. Your records will be kept in locked files and only study staff will be allowed to look at them. The reporting of the experimental results will only contain group mean results and will contain no personal information about individual participants. Your name and other personally identifying information will not appear when results of this study are presented or published. Records will be viewed, stored, and maintained in private, secure files only accessible by the P.I. for three years following the study, after which time they will be destroyed.

WKU IRB# 20-189
Approved: 1/31/2020
End Date: 1/20/2021
EXPEDITED
Original: 1/31/2020

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

____ _______________
Signature of Participant Date

____ _______________
Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Robin Pyles, Human Protections Administrator
TELEPHONE: (270) 745-3360

WKU IRB# 20-189
Approved: 1/31/2020
End Date: 1/20/2021
EXPEDITED
Original: 1/31/2020

Appendix B

Informed Consent of the Main Study

IMPLIED CONSENT DOCUMENT

Project Title: Face Memory Task
Investigator: Dr. Andrew Mienaltowski, Psychological Sciences, WKU, (270) 681-0270

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your consent to participate in this project.

You must be 18 years old or older to participate in this research study.

This study is presented online via PsyToolkit. This platform is compatible with **Google Chrome, Microsoft Edge, and Mozilla Firefox web browsers.** Other browsers (e.g., Apple Safari) may not be compatible. A basic explanation of the project is written below. Please read this explanation and email the researcher any questions you may have. If you then decide to participate in the project, please continue to the survey(s). You should keep a copy of this form for your records.

1. **Nature and Purpose of the Project:** This study investigates your short-term memory for faces. Your role as a participant is to complete a short-term memory test and a few other measures that will allow us to understand how people remember faces.

2. **Explanation of Procedures:** In this study, you will complete a demographics form and some brief measures of cognitive ability and emotionality. You will also complete a task where you observe a number of facial images and try to remember them over a very short-period of time. In this task, you will see a face, and then, after a short delay, you will be asked to choose which face of two was the target face you had studied. The study should take no more than 75 minutes (1.25 hours) to complete.

3. **Discomfort and Risks:** There are no known or anticipated risks to those participating. Participants are free to end the experiment at any time, in the event that they experience fatigue or boredom.

4. **Benefits:** There are no direct benefits for participating. Your participation helps us to understand how people remember faces. Individuals who take part in this study via Study Board will earn 5 credits (1 credit/15 minutes). Individuals from Mechanical Turk/Prolific will be compensated $12.50.

5. **Confidentiality:** During this study, you will be asked for some personal information (age, gender, etc.). This information will be confidential and will only be used by the experimenter. The data collected will be kept private. To protect your privacy, your records will be kept under a code number rather than by name. Your Amazon Worker/Prolific IDs and a second code are used to connect you to your data for compensation. However, the second code is used as your participant identification when aggregating data. Your records will be kept in locked files and only study staff will be allowed to look at them. Reported experimental results will only contain group results and will contain no personal information about individual participants. Your name and other personally identifying information will not appear when results of this study are presented or published. To make sure that this research is being carried out in the proper way, the Western Kentucky University Human Subjects Review Board will review study records.

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

Your continued cooperation with the following research implies your consent.

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Robin Pyles, Human Protections Administrator
TELEPHONE: (270) 745-3360

WKU IRB# 20-189
Approved: 4/22/2020
End Date: 1/21/2021
EXPEDITED
Original: 1/31/2020

Appendix C

Updated Informed Consent of the Main Study

INFORMED CONSENT DOCUMENT

Project Title: Face Memory Task

Investigator: Dr. Andrew Mienaltowski, Psychological Sciences, WKU, (270) 681-0270

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your consent to participate in this project.

You must be 18 years old or older to participate in this research study.

This study is presented online via PsyToolkit. This platform is compatible with **Google Chrome, Microsoft Edge, and Mozilla Firefox web browsers.** Other browsers (e.g., Apple Safari) may not be compatible. This form includes information on the purpose of the project, the procedures used, and the potential benefits and possible risks of participation. A basic explanation of the project is written below. Please read this explanation. If you then decide to participate, there will be a place to indicate this below.

1. **Nature and Purpose of the Project:** This study investigates your short-term memory for faces. Your role as a participant is to complete a short-term memory test and a few other measures that will allow us to understand how people remember faces.
2. **Explanation of Procedures:** In this study, you will complete a demographics form and some brief measures of cognitive ability and emotionality. You will also complete a task where you observe a number of facial images and try to remember them over a very short-period of time. In this task, you will see a face, and then, after a short delay, you will be asked to choose which face of two was the target face you had studied. The study should take no more than 75 minutes (1.25 hours) to complete.
3. **Discomfort and Risks:** There are no known or anticipated risks to those participating. Participants are free to end the experiment at any time, in the event that they experience fatigue or boredom.
4. **Benefits:** There are no direct benefits for participating. Your participation helps us to understand how people remember faces. Individuals who take part in this study via Study Board will earn 5 credits (1 credit/15 minutes). Individuals from Mechanical Turk/Prolific will earn at least $12.50 (~$10/hour) for completing the study, provided you follow instructions and pass attention checks.
5. **Confidentiality:** During this study, you will be asked for some personal information (age, gender, etc.). This information will be confidential and will only be used by the experimenter. The data collected will be kept private. To protect your privacy, your records will be kept under a code number rather than by name. Your Amazon Worker/Prolific IDs and a second code are used to connect you to your data for compensation. However, the second code is used as your participant identification when aggregating data. Your records will be kept in locked files and only study staff will be allowed to look at them. Reported experimental results will only contain group results and will contain no personal information about individual participants. Your name and other personally identifying information will not appear when results of this study are presented or published. To make sure that this research is being carried out in the proper way, the Western Kentucky University Human Subjects Review Board will review study records.
6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

Your continued cooperation with the following research implies your consent.

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Robin Pyles, Human Protections Administrator
TELEPHONE: (270) 745-3360

INSTITUTIONAL REVIEW BOARD WKU APPROVED

WKU IRB# 20-189
Approved: 7/14/2020
End Date: 1/21/2021
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Original: 1/31/2020