Brief Affect Recognition Thresholds:
A Systematic Evaluation of The Japanese and Caucasian Brief Affect Recognition Test

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Abstract

Micro-expressions are brief facial expressions of emotion (40 to 500 ms) that are posited to represent true reflections of an individual's emotional state that have 'leaked' through voluntary attempts to neutralize or mask the involuntary expression. As such, correct recognition can have important benefits. The Japanese and Caucasian Brief Affect Recognition Task (JACBART) has been proposed as the standardized measure of affect recognition capabilities with micro-expression durations (i.e., facial expressions lasting less than 500 ms). In this paradigm target expressions of emotion are briefly presented between two neutral expressions. However, limited research has explored the temporal thresholds and the various factors that may influence performance in a JACBART paradigm. In three studies, the current thesis sought to determine the effects of a forward mask with a variable duration (Study 1), the inclusion/exclusion of a 'neutral' response category (Study 2), and expressions portrayed at lower intensities (Study 3). Although a variable-duration forward mask was found to have little effect on performance, significant effects were observed for the inclusion of a 'neutral' response option and when reducing the expression intensity. In addition, a trend was observed across all three studies that demonstrated a recognition advantage for expressions of happiness and surprise. Performances for these two expressions exceeded the psychometric threshold with durations of as little as 5 to 10 ms, whereas presentation times as long as 113 ms were necessary to elicit above-threshold recognition rates with negative emotions (i.e., anger, disgust, fear, and sadness). Altogether, the current findings present some methodological considerations for studies interested in measuring brief affect recognition with a JACBART paradigm. More generally, they expand our understanding of how various relevant factors affect the speed at which facial expressions can be processed.

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Table of Contents

List of Tables

Study 1

Study 2

Study 3

Appendix A

Appendix B

List of Figures

Study 1

Study 2

Study 3

Appendix A

Appendix B

Appendix C

Abbreviations

AU	Action Unit
AFC	Alternative Forced-Choice
BART	Brief Affect Recognition Test
FACS	Facial Action Coding System
IAPS	International Affective Picture System
ISPR	Integrated System of Participation in Research
JACBART	Japanese and Caucasian Brief Affect Recognition Test
JACFEE	Japanese and Caucasian Facial Expressions of Emotion
KDEF	Karolinska Directed Emotional Faces
SOA	Stimulus-Onset Asynchrony

General Introduction

In the study of facial expressions of emotion, there has been a long-standing belief that the ability to portray and understand expressions of emotion benefits an individual's social and communication skills (e.g., Ambady et al., 1995; Elfenbein et al., 2007; Hall, 2001; Matsumoto & Hwang, 2011; Plutchik, 2001; Rosenthal et al., 1979; Shariff & Tracy, 2011). For instance, the display of specific expressions of emotion could be used to portray dominance, alert others of possible danger, pacify an aggressor, seek protection, facilitate reproduction, or dispel someone's fears (Plutchik, 2001; Shariff & Tracy, 2011). Meanwhile, the ability to accurately recognize expressions of emotion has been related to—besides the evolutionary benefit of avoiding potential danger (e.g., Sorce et al., 1985)—effective negotiation skills, workplace performance, relationship well-being, intercultural adjustment, and emotion regulation (Carton et al., 1999; Elfenbein et al., 2007; Hall, 2001; Rosenthal et al., 1979; Yoo et al., 2006). Together, this collection of research highlights two major components of affect recognition: the expresser and the observer.

When the expresser is considered, there are two biologically distinct types of expressions of emotion an individual may display in their face: involuntary and voluntary expressions (Gothard, 2014; Korb, Grandjean, Scherer, 2008; Rinn, 1984). In this case, an involuntary expression of emotion could be viewed as a reflexive emotional response to a situation that results in a facial expression. Alternatively, a voluntary expression would be manufactured by the individual themselves to either simulate an emotion they do not feel, minimize or neutralize an emotion they do feel, or hide their true emotion with the simulation of another (Ekman, 1985/2009; Ekman & Friesen, 1969). Understandably, this more deceptive type of facial expression could be advantageous for the expresser in manipulating or hiding their true opinions (see Matsumoto et al., 2008).

Voluntary manipulations of facial affect are not perfect. Difficulties can, for instance, be observed with the suppression of an expression of emotion. Darwin's (1872) Inhibition Hypothesis proposes that the attempt to suppress an expression of emotion can lead to involuntary leakage. Evidence of this was first reported by Haggard and Isaacs (1966), after observing "micro-momentary facial expressions" while examining video recordings of psychotherapy sessions at approximately 1/6th their normal speed. However, these brief expressions of emotion (i.e., *micro-expressions*) were not attributed to emotional leakage until further observations by Ekman and Friesen (1969, 1974). Micro-expressions were suggested to differ from typical involuntary expressions, as they are only thought to be displayed for up to 500 ms (Ekman, 1985/2009; Ekman & Rosenberg, 2005; Frank et al., 2009; Frank & Svetieva, 2015; Matsumoto & Hwang, 2011). Conversely, involuntary expressions are typically reported to be displayed for between 0.5 and 4 seconds (i.e., *macro-expressions*; Ekman, 2003; Hess & Kleck, 1990). However, despite the importance of duration in defining a micro-expression, there is a surprising lack of consistency in the literature in delineating how long such expressions last. For instance, micro-expressions are commonly defined by Ekman (1985/2009; Ekman & Friesen, 1975) as lasting between 40 and 200 ms, but have also been defined to last up to 1/3rd of a second (Ekman & Rosenberg, 2005) or 500 ms (Frank et al., 2009; Frank & Svetieva, 2015; Matsumoto & Hwang, 2011). This is further complicated by the limited empirical data with micro-expressions (see Porter and ten Brinke, 2008, or Yan et al., 2013).

In the first empirical demonstration of micro-expressions, Porter and ten Brinke (2008) instructed participants to exhibit specific expressions while viewing emotionally arousing images from the International Affective Picture System (IAPS; Lang et al., 1993, 2008). More specifically, while viewing an image (e.g., neutral, happy, or sad), participants would be instructed to maintain a specific expression (e.g., neutral, disgust, happiness, sadness, or fear). As such, a micro-expression would be any facial muscle activity that is unrelated to the instructed expression (e.g., the expression of any emotion when instructed to maintain a neutral face). Video recordings taken throughout this task were then examined frame-by-frame at 30 Hz by trained Facial Action Coding System coders (FACS; Ekman & Friesen, 1978; Ekman et al., 2002). Their task was to identify specific facial muscles activated in each frame (i.e., action units; AUs). Although no full micro-expressions (i.e., including both the upper and lower part of the face) were observed to meet the definition proposed by Ekman and Friesen (1975; i.e., durations between 40 and 200 ms), Porter and ten Brinke (2008) report that partial micro-expressions were observed in the upper or lower half of the face with approximately 2% of the analyzed expressions. In addition, when the task involved hiding the emotion invoked by the image (i.e., masked and neutralized expressions), the observed micro-expression was always congruent with the affect portrayed in the image. Finally, Porter and ten Brinke (2008) noted a concern with the definition that micro-expressions are only displayed between 40 and 200 ms (see Ekman & Friesen, 1975)—as they report observing emotional leakage lasting more than a second.

As discussed, there is considerable inconsistency regarding the duration of a micro-expression, and some have argued that a micro-expression may last up to 500 ms (Frank et al. 2009; Frank & Svetieva, 2015; Matsumoto & Hwang 2011). To better understand the timeline of micro-expressions, Yan and colleagues (2013) conducted a similar study to Porter and ten Brinke's (2008). They instructed participants to maintain a neutral expression while viewing emotionally arousing videos. However, their study included two important differentiations: (1) participants were motivated to maintain neutrality through instruction that their performance would influence their monetary reward for participating and (2) micro-expressions were defined as any expression of 500 ms or less. By incentivizing their participants to maintain a neutral expression, Yan and colleagues (2013) simulated a high-stake situation where failure results in a punishment. The latter differentiation was specifically chosen to address the concern that the 40 to 200 ms definition may be too stringent. As such, the 500 ms upper limit was selected because it represents the largest upper limit used to define a micro-expression (Frank et al. 2009; Matsumoto & Hwang 2011) and the lower limit of a macro-expression (Ekman, 2003; Hess & Kleck, 1990).

Trained coders evaluated the facial recordings at 60 Hz and extracted expressions that were presented for up to 500 ms. Of the 1000 facial expressions observed by Yan and colleagues (2013), only 109 cases met their criteria for a micro-expression. A frequency analysis was then used to assess the upper and lower limits of the observed micro-expression duration. Based on the fitting curve, results indicated that 95% of the observed micro-expressions had durations between 169 and 502 ms, with an average duration of 314 ms. As such, they report the 500 ms upper limit for micro-expressions (Frank et al. 2009; Matsumoto & Hwang 2011) was supported by empirical evidence. Conversely, the 40 ms lower limit for micro-expressions (Ekman & Friesen, 1975) was not supported. Instead, Yan and colleagues (2013) indicate they did not observe any micro-expressions with a duration shorter than 100 ms.

With such brief displays, there is naturally a concern that individuals may have difficulty detecting and recognizing micro-expressions. Indeed, Haggard and Isaacs (1966) initially claimed that these brief expressions of emotion were beyond human detection and required videos to be slowed. However, Ekman refuted this claim and described using a tachistoscope to present expressions for very brief durations (e.g., 40 ms) in a test called the Brief Affect Recognition Test (BART; Ekman, 2003; Ekman & Friesen, 1974; Ekman & O'Sullivan, 1991).

An example of BART task is observed with Kirouac and Doré (1984). In their study, a tachistoscope was used to present expressions of the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) for durations ranging from 10 to 50 ms. Although the analyses are not reported, Kirouac and Doré (1984) report that recognition rates with these brief expressions were relatively high compared to those previously observed with expressions presented for 10 seconds (Kirouac & Doré 1982). It is also unclear if recognition rates exceeded chance performance (i.e., 17%)—as it is a not discussed and mean accuracies are presented without any measure of variability. Notwithstanding, with recognition rates of 27% and greater, it is probable that performances exceeded chance levels with all emotions presented for at least 20 ms. Finally, Kirouac and Doré (1984) suggest that the benefits of longer durations differed across emotions. The interpretation of these differences is however complicated by the very brief nature of the expressions. For instance, they suggest that recognition performance plateaus at 30 ms with expressions of happiness. The range of durations examined may however be too narrow for the benefits of longer presentation time to be accurately observed. That is, it is unclear from this research if durations of greater than 50 ms, ranging up to 500 ms, might yield better performance.

Rectifying this issue, Calvo and Lundqvist (2008) presented the six basic emotions from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist et al., 1998) in a BART paradigm with durations of 25, 50, 100, 250, and 500 ms. In addition, a separate group was provided an unlimited duration to categorize the expressions. The aim of their study was to explore the recognition thresholds. Calvo and Lundquist (2008) report a significant interaction between presented emotion category and presentation duration in determining performance. Despite this, they discuss a main effect of duration. Specifically, they claim that increasing durations continuously benefit affect recognition up to 200 ms, at which point performance plateaus, showing no increase in performance with 500 ms and unlimited durations. With all hit rates greater than 70%, recognition performances were also quite high regardless of the duration. However, their examination of the interaction suggests recognition performances with expressions of fear were poorer than those of sadness when displayed for 25 to 250 ms, and poorer than those of anger when displayed for 50 to 500 ms. Conversely, recognition rates with expressions of happiness outperformed all other emotions. This decision to explore the effect of emotion type on recognition at each expression duration was unexpected for a study intending to explore the recognition thresholds—as it does not speak to the differing effects of duration on emotion recognition. Instead, it appears to prioritize evaluating the ability to recognize the expressions in their new KDEF image database.

With the growing literature measuring brief affect recognition, Ekman (2003) described having to redesign the BART to accommodate growing evidence that the paradigm allows for post-offset processing that could facilitate recognition performances. For instance, Esteves and Ohman (1993) conducted several important experiments exploring the role a stimulus presented immediately after a target expression (i.e., a backward mask).

One such experiment (experiment 2) explored the effect of the delay in mask's onset following the target's onset (i.e., stimulus-onset asynchrony; SOA) in two paradigms with angry and happy expressions presented for 30 ms. However, participants were instructed to either categorize the expressions in a forced-choice task (i.e., a recognition task) or indicate if they saw one or two images (i.e., a discrimination task). Neutral expression backward masks, with a different actor than that presented in the target, were then presented for 30 ms with an SOA of 30, 60, 70, 90, 120, 180, or 230 ms (i.e., 0, 30, 40, 60, 90, 150, or 200 ms after target-offset). In addition, Esteves and Ohman (1993) suggest they accounted for potential response biases in the task by presenting 60 ms neutral target expressions, as means of determining the chance baselines for the two response options (i.e., 'angry' and 'happy') in the emotion categorization task. They report that performances demonstrated a general improvement as the onset of the mask grew further from the target's offset, with greater recognition and discrimination rates. Indeed, happy expression recognition and discrimination was only at chance level when presented with a 30 ms SOA (i.e., immediately following target offset). Conversely, anger expression recognition and discrimination were respectively observed at chance level with SOAs up to 180 ms and 60 ms. This performance may however have been impacted by the observed response bias for the 'angry' option with neutral expressions—as it consequently raised their chance threshold for angry expressions. Nevertheless, the current experiment demonstrates that the backward mask had a greater impact on recognition and discrimination performances when it was presented immediately following the 30 ms target expression—as it interrupts post-offset processing.

A second important experiment by Esteves and Ohman (1993) explored the role of the backward mask's duration in two paradigms (experiment 4). In one task, angry and happy expressions were again presented for 30 ms and followed by a mask with an SOA of 30, 60, 120, or 240 ms (i.e., the mask onset was 0, 30, 90, or 210 ms after target offset). In a second task, the expressions were presented for 30, 60, 120, or 240 ms and immediately followed by the onset of a mask (i.e., the duration of the target matched the SOA and the mask onset was always 0 ms after target offset). Backward masks always included a neutral expression displayed for 30, 60, or 120 ms. Esteves and Ohman (1993) interestingly report that the duration of the mask had no effect on recognition performances, and differences were not observed between the two tasks. Conversely, recognition rates were again observed to continuously improve with longer SOAs regardless of the target's duration (i.e., 30 ms vs duration of the SOA). Together, this experiment has two important implications: (1) the improved recognition with longer SOAs can be attributed to longer processing times whether it is during the expression's presentation or post-offset, and (2) a 30 ms backward mask is sufficient to interrupt post-offset processing of the target regardless of SOA and expression duration.

Having established the importance of a backward mask when measuring brief affect recognition, Milders and colleagues (2008) sought to further test recognition performances with angry, fearful, happy, and neutral expressions displayed for 10, 20, 30, 40, and 50 ms. This task can be compared to that previously administered by Kirouac and Doré (1984), but all expressions were immediately followed by a 300 ms neutral expression mask portrayed by a different actor. In addition, some trials only presented the 300 ms mask (i.e., mask-only trials). In this first experiment, participants were instructed to both categorize the expression and rate their awareness of the expression on a 9-point Likert scale. Results demonstrated that performance, A' sensitivity estimates, was generally better with expressions of happiness than the other expressions with durations greater than 10 ms. In addition, Milders and colleagues (2008) report that recognition exceeded chances levels at 10 ms durations with angry, happy, and neutral expressions. Conversely, 20 ms was needed for expressions of fear. Participants were also more likely to report awareness of the 10 ms fearful, happy, and neutral expressions relative to their respective mask-only trial baselines, whereas greater awareness for angry expressions was only observed with 20 ms durations.

In a second experiment, Milders and colleagues (2008) repeated the task previously described but replaced the neutral expression mask with a dynamic checkerboard that reversed its luminance. It was originally hypothesized that this dynamic mask would lead to greater expression recognition interference than the static neutral expression masks. However, all 10ms expressions demonstrated performances, A' sensitivity and awareness ratings, above chance levels with the dynamic checkerboard mask. Milders and colleagues (2008) also report that sensitivity and awareness ratings were greater with the dynamic checkerboard mask than with the neutral expression masks. As such, it was suggested that greater target-mask configural similarity contributed to a greater masking effect (see also Loffler and colleagues, 2005).

As an alternative to the BART, the Japanese and Caucasian Brief Affect Recognition Test (JACBART; Matsumoto et al., 2000) was proposed as a standardized way for researchers to measure brief expression recognition. In this paradigm, Matsumoto and colleagues (2000) presented 1000 ms videos with an expression of emotion displayed in the middle of two neutral expressions of that same actor (i.e., forward and backward masks). In an initial experiment (experiment 1), three target durations (67, 133, or 200 ms) were used with 9-point Likert scales (0 = Not at all, 8 = A lot) rating the presence, or absence, of each of the labels associated with the target expressions (anger, contempt, disgust, fear, happiness, sadness, and surprise). However, Matsumoto and colleagues (2000) recognized the difficulty with this multi-scalar task, and therefore administered the JACBART using a forced-choice task with label options for each of the target expressions (anger, contempt, disgust, fear, happiness, sadness, and surprise). In addition, all further studies only displayed target expressions for a single duration throughout the study (i.e., 133 or 200 ms).

Acceptable internal consistency was observed with JACBART recognition rates across all five experiments (all Cronbach's $\alpha \geq .82$), and intercorrelations suggest there was support for the convergent validity with the JACBART. One experiment (experiment 3) also measured test-retest reliability with two sessions separated by 3 to 4 weeks, demonstrating a significant positive correlation across sessions ($r_{\text{total}} = 0.78$). Finally, concurrent validity was observed with the JACBART through comparisons to a variety of personality tests, with recognition rates generally demonstrating a positive correlation with openness and conscientiousness traits (experiments 1, 2, and 5). Matsumoto and colleagues (2000) argued that people with increased openness traits would be more attentive and receptive to their surroundings, thus making them more in tune with reading emotions in others. Conversely, conscientiousness may be associated with brief affect recognition rates because these individuals often pay greater attention to detail and may be better at discerning the details in facial expressions. Finally, despite it only being observed with one personality scale, there was some evidence that recognition rates are positively related to extraversion but negatively related to neuroticism (experiment 4). Matsumoto and colleagues (2000) suggest that the positive relationship with extraversion is attributable to extroverts being more social and conscious of the emotions of others. Conversely, the negative relationship with neuroticism may be because emotionally stable individuals are better able to attend to others, while someone that is in an unstable state may focus more on themself.

The improvement gained with the JACBART was further demonstrated by Shen and colleagues (2012), where recognition rates with the BART were compared to those with the JACBART. Facial expressions of the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) were presented for 40, 120, 200, and 300 ms. Resulting recognition rates with the BART and JACBART were benefited by the longer expression durations up to 200 ms. In addition, the two recognition tasks were observed to significantly differ when the expression was presented for 40 ms. A particularly problematic finding when interpreting studies that explored very brief emotion recognition without masks (e.g., Calvo & Lundqvist, 2008; Ekman & Friesen, 1974; Ekman & O'Sullivan, 1991; Kirouac & Doré, 1984). In addition, despite exceeding chance (17%) with durations as little as 40 ms, hit rate figures appear to suggest that longer durations are required for JACBART performances to reach a more acceptable level (i.e., 58% based on the theoretical psychometric threshold). However, results also appear to suggest this may not have been the case with all emotions. More specifically, Shen and colleagues (2012) suggest happiness was generally more easily recognized, while increased difficulty was observed with expressions of anger and fear.

The observed difficulty with brief facial expressions of emotion is particularly relevant in high-stakes situations, where accurate recognition of the deception is imperative (see Porter and ten Brinke, 2010). A plethora of research has therefore explored the benefits of training on recognition performances (e.g., Marsh et al., 2010, Matsumoto & Hwang, 2011, Matsumoto et al., 2014, Porter & ten Brinke, 2010, Russell et al., 2006; Russell et al., 2008). Although the ability to learn would have important implications for situations where accurate emotion recognition could save lives (see Matsumoto et al., 2014, for a study with the Federal Bureau of Investigation) or enhance clinical interventions (e.g., Marsh et al., 2010; Russell et al., 2006; Russell et al., 2008), research exploring the measure of recognition performance is still limited (Esteves and Ohman, 1993; Matsumoto et al., 2000; Maxwell & Davidson, 2004; Milders et al., 2008; Shen et al., 2012; Zhang et al., 2014). It should however be noted that the popular training tools by Paul Ekman Group (https://www.paulekman.com/micro-expressions-training-tools/) and Matsumoto’s Humintell (https://www.humintell.com/products-2/) employ a pre-test/post-test design using the JACBART to measure recognition performance as an indicator of training effect.

Interestingly, despite the JACBART being proposed as a standardized measure and the limited research exploring the paradigm, it has been inconsistently applied in the literature. For instance, the forward mask is at times displayed for a fixed duration (e.g., Matsumoto & Hwang, 2011; Shen et al., 2012; Zhang et al., 2014) or a duration that varies according to the duration of target stimulus (e.g., Hall & Matsumoto, 2004; Hurley, 2012; Hurley et al., 2014; Matsumoto et al., 2000)—to obtain a consistent target and masks duration sum across all trials. The use of a fixed forward mask duration could be problematic in the JACBART, as studies have demonstrated that individuals are quite efficient at learning to devote their attention to specific timeframes. For instance, primes with temporal information are observed to benefit target recognition when compared to uninformative primes (e.g., Coul & Nobre, 1998). Thus, a fixed forward mask duration in the JACBART could facilitate emotion recognition and impact studies of stimulus duration thresholds. This issue is examined in Study 1 of the present thesis, where we compare the effects of fixed-duration vs. random-duration forward masks on emotion recognition in the JACBART paradigm.

Applications of the JACBART are also observed to differ in the response options provided. Matsumoto and colleagues (2000) initially proposed the forced-choice JACBART, with a design that exclusively included the emotion labels for the expressions presented in the task (see also Shen et al., 2012). Conversely, some more research literature has included ‘none of the above’ and/or ‘neutral’ options (e.g., Hurley, 2012; Hurley et al., 2014; Matsumoto &

Hwang, 2011). Matsumoto and Hwang (2011) suggested that these additional options should be included to prevent artifactual agreement. However, the research cited for this justification (i.e., Frank & Stennett, 2001) was not conducted with brief facial expressions of emotion—as participants were given as much time as needed to categorize the expression. It is therefore unclear how the introduction of the response options could impact brief affect recognition performances. This is examined in Study 2 of the current thesis, where we compare the effects of a JACBART paradigm with and without a ‘neutral’ option on emotion recognition.

Finally, despite evidence that micro-expressions are often presented as subtle expressions (Porter & ten Brinke, 2008; Yan et al., 2013), there is no known research that has explored the recognition of brief displays of subtle expressions. This is consistent with most facial expression research, where subtle expressions obtain less focus in general (Matsumoto & Hwang, 2014). It is therefore important to understand how brief affect recognition performance differs between full and subtle expressions. This issue is examined in Study 3, where we compare the effects of 100% intensity and 50% intensity expressions on emotion recognition in the JACBART paradigm.

Study 1

Effects of Forward Mask Duration Variability on the Temporal Dynamics of Brief Facial Expression Categorization

Study 1 was published in i-Perception in 2023.

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Abstract

The Japanese and Caucasian Brief Affect Recognition Task (JACBART) has been proposed as a standardized method for measuring people's ability to accurately categorize briefly presented images of facial expressions. However, the factors that impact performance in this task are not entirely understood. The current study sought to explore the role of the forward mask's duration (i.e., fixed vs. variable) in brief affect categorization across expressions of the six basic emotions (i.e., anger, disgust, fear, happiness, sadness, and surprise) and three presentation times (i.e., 17, 67, and 500 ms). Current findings do not demonstrate evidence that a variable-duration forward mask negatively impacts brief affect categorization. However, efficiency and necessity thresholds were observed to vary across the expressions of emotion. Further exploration of the temporal dynamics of facial affect categorization will therefore require a consideration of these differences.

Keywords: Emotions, Facial Expressions, Stimulus Duration, Thresholds, Masking

Effects of Forward Mask Duration Variability on the Temporal Dynamics of Brief Facial Expression Categorization

Individuals have an inherent faculty to voluntarily control the facial expressions they portray to others, which enables them to either simulate an emotion they do not feel, minimize or neutralize an emotion they do feel, or hide their true emotion with the simulation of another (Ekman, 1985/2009; Ekman & Friesen, 1969; Zuckerman et al., 1981). The portrayal of voluntary facial expressions can, for obvious reasons, be advantageous for the expresser when they intend manipulate others (Zuckerman et al., 1981). However, in line with Darwin's (1872) Inhibition Hypothesis, this expression control is not absolute and involuntary leakage can unintentionally result in brief demonstrations—appearing for less than 0.5 seconds—of an emotion the individual is trying to conceal (Ekman, 1985/2009; Ekman & Friesen, 1974; Haggard & Isaacs, 1966; Yan et al., 2013). These brief emotional leakages—often termed *micro-expressions*—are suggested to differ from typical involuntary expressions, which are otherwise known as *macro-expressions* and portrayed for between 0.5 and 4 seconds (Ekman, 2003; Hess & Kleck, 1990).

Although empirical data concerning the production of micro-expressions are still limited due to their nature (see Porter & ten Brinke, 2008, or Yan et al., 2013), there is a great deal of research exploring their categorization (e.g., Calvo & Lundqvist, 2008; Ekman & Friesen, 1974; Esteves & Öhman, 1993; Marsh et al., 2010; Matsumoto & Hwang, 2011; Matsumoto et al., 2000; Matsumoto et al., 2014; Milders et al., 2008; Porter & ten Brinke, 2010; Russell et al., 2006; Russell et al., 2008; Shen et al., 2012). Observers are predictably found to have increased difficulty accurately recognizing these brief expressions—as compared to full-duration macro-expressions. Indeed, longer display times were found to benefit brief affect categorization (Calvo & Lundqvist, 2008; Kirouac & Doré, 1984).

There is, however, evidence (e.g., Marsh et al., 2010, Matsumoto & Hwang, 2011, Matsumoto et al., 2014, Porter & ten Brinke, 2010, Russell et al., 2006, Russell et al., 2008) that individuals are capable of improving their ability to efficiently recognize these brief expressions through training, which has important implications for high-stakes situations where accurate emotion recognition could save lives (e.g., see Matsumoto et al., 2014) or enhance clinical interventions (e.g., Marsh et al., 2010; Russell et al., 2006; Russell et al., 2008). As a result, although outside the scope of the current study, training programs have been developed to purportedly increase a person's micro-expression recognition abilities—examples can be accessed through the Paul Ekman Group (https://www.paulekman.com/micro-expressions-training-tools/) or Matsumoto's Humintell (https://www.humintell.com/products-2/).

These training programs are of particular relevance to the current study because the Japanese and Caucasian Brief Affect Recognition Task (JACBART) was developed as a standardized measure of brief affect recognition pre- and post-training, as an assessment of training effectiveness. The JACBART proposes that a target facial expression of emotion should be presented for a brief amount of time between two neutral expressions of that target (i.e., a neutral expression of the same individual presenting the target expression is used as both a forward and backward masks). The observer is then typically asked to select which emotion the target expression portrayed (e.g., Hurley, 2012; Hurley et al., 2014; Matsumoto & Hwang, 2011; Matsumoto et al., 2000).

The introduction of the neutral expression after the target expression (i.e., a backward mask) with the JACBART—as compared to the Brief Affect Recognition Test (BART; see

Ekman & Friesen, 1974)—was thought to serve an important function beyond simply increasing the measure's ecological validity. More specifically, it was thought this approach would reduce the likelihood that a brief target image would leave a residual afterimage in the early stages of the visual system, which could consequently facilitate post-offset processing of the target and lead to increased recognition rates (e.g., Bacon-Macé et al., 2005; Shen et al., 2012). Indeed, the duration (Esteves & Öhman, 1993; Macknik & Livingstone, 1998) and type (Loffler et al., 2005; Milders et al., 2008; Zhang et al., 2014) of backward mask have been observed to impact brief affect recognition thresholds. More specifically, a backward mask of at least 50 ms is suggested to significantly lower recognition rates (Esteves & Öhman, 1993; Macknik & Livingstone, 1998), and a neutral-face backward mask was found to add increased affect recognition difficulty as compared to a dynamic checkerboard backward mask (Milders et al., 2008; see, also, Loffler et al., 2005).

Despite the many studies demonstrating the impact of a backward mask on brief affect recognition, there is little research exploring the role of the forward mask (Esteves & Öhman, 1993; Macknik & Livingstone, 1998). Indeed, the JACBART commonly displays a forward mask for a fixed-duration (e.g., Matsumoto & Hwang, 2011; Shen et al., 2012; Zhang et al., 2014) or a duration that varies systematically to obtain a fixed-duration sum across the target and mask durations (e.g., Hurley, 2012; Hurley et al., 2014; Matsumoto et al., 2000). Furthermore, even with the latter approach, the forward mask varied by at most 65 ms within an experiment.

This presents a potential limitation for the JACBART because individuals have demonstrated an ability to devote their attention to specific timespans. For instance, primes with temporal information have been found to benefit target recognition, when compared to primes without temporal meaning (Coull & Nobre, 1998). Consequently, a fixed forward mask duration could facilitate emotion recognition and impact recognition thresholds for the JACBART by allowing participants to use the forward mask onset as a prime to predict the target onset.

The current study was therefore designed to explore the impact of forward mask duration variability on emotion categorization performances with brief expressions of emotion in a JACBART paradigm. The current study presented target expressions for either 17, 67, or 500 ms (i.e., 1, 4, or 30 frames on a 60 Hz display monitor)—as 17 ms was the shortest time for which one can present a visual stimulus on a standard 60 Hz monitor, 67 ms is the shortest time typically employed with the JACBART (e.g., Matsumoto et al., 2000), and 500 ms is thought to yield performances equivalent to unlimited viewing (Calvo & Lundqvist, 2008) and represents the threshold between micro-expressions and macro-expressions. The version of the JACBART employed by Matsumoto and Hwang (2011) was modified such that the stimuli appeared either after a *fixed-duration* (1,000 ms) or *variable-duration* (750 – 1,250 ms) forward mask. By then asking participants to correctly categorize the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) with the three target durations, the current study sought to explore forward mask variability's relationship with the *necessity threshold*—the minimum presentation time needed to recognize facial expressions at a rate significantly above chance—and the *efficiency threshold*—defined as the minimum presentation time required for a brief facial expression to be recognized at a rate statistically equivalent to a macro-expression (i.e., a duration of 500 ms or more). It was hypothesized that the variable-duration forward mask would reduce a participant's ability to predict the onset of the target expression. This increased difficulty would be reflected through lower hit rates and greater erroneous response rates, and consequently increase the necessity and efficiency thresholds. That is, both above-chance performance and ceiling-level performance would be expected to require longer target durations.

Two additional hypotheses were also formulated with respect to these categorization thresholds. First, based on research with fixed-duration pre-target fixation screens (i.e., without a forward mask; Milders et al., 2008; Pessoa et al., 2005), the necessity threshold was hypothesized to vary across the six basic emotions. More specifically, it was predicted that 17 ms would be sufficient for the recognition of angry and happy expressions at rates above chance, while 67 ms would be needed for expressions of fear. For the remaining emotions, due to a lack of information in previous studies, it was unclear whether 17 ms would be sufficient to yield above-chance performances. Second, Calvo and Lundqvist (2008) suggest 67 ms may not be sufficient for categorization performances to meet the current efficiency threshold definition with any expressions of emotion. However, despite their interaction between display time and displayed emotion, they did not consider how display time could have varying effects across emotions—opting to, instead, collapse their data across emotion conditions. It was therefore hypothesized that the efficiency threshold would vary across expressions of emotion.

Methods

Participants

Thirty undergraduate students were recruited to participate in the current study. These individuals were randomly assigned one of two forward mask groups: *Fixed-Duration* or *Variable-Duration*. There were 13 individuals in the Fixed-Duration group (5 males, 8 females; M_{age} = 18.38, *SD* = 0.77 years) and 17 in the Variable-Duration group (2 males, 15 females; M_{age} = 19.71, *SD* = 4.25 years). All participants were recruited through an undergraduate participant pool, the Integrated System of Participation in Research (ISPR), at the University of Ottawa. Participants completed the experiment individually for course credit in the Integrated Neurocognitive and Social Psychophysiology Interdisciplinary Research Environment

(INSPIRE) lab at the University of Ottawa. Although they were tested in groups of up to 4 individuals, each completed the task on a separate computer shielded from the others by a carrel. All participants in a given session were placed in the same forward mask group.

Materials

E-Prime v2.3 (Psychology Software Tools, Sharpsburg, PA) was used to present a total of 216 trials on ViewSonic VT2405 monitors with a 60 Hz refresh rate and 1920 x 1080 pixel resolution. Stimuli consisted of a total of 24 target images taken from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE; Matsumoto & Ekman, 1988) database. This included images of two male and two female Caucasian models each displaying facial expressions of all six basic emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise). In addition, the neutral face images of all four models were used as their respective target expression masks. All images were cropped such that the emotionally expressive faces would align with their neutral counterparts, which served to reduce the degree of apparent motion induced by the switch between the neutral mask images and the target images.

Procedure

A modified JACBART paradigm was used (Matsumoto et al., 2000; Matsumoto & Hwang, 2011), where a target expression was always presented between two neutral expressions portrayed by the same actor (see Figure 1). Each trial began with the display of a neutral facial expression for either 1,000 ms (Fixed-Duration group; see Matsumoto & Hwang, 2011) or a random duration between 750 and 1,250 ms (Variable-Duration group; with 17 ms increments). The target expression was then displayed for one of three set durations (17[1], 67, or 500 ms) and

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[1] Due to software limitations (see Garaizar et al., 2014), the 1 frame (17 ms) target stimuli were at times presented for 2 frames (33 ms). All 33 ms trials were removed from further analyses with the current participants.

followed by the neutral expression image for 1,000 ms. The participant was then asked to indicate which expression was displayed by selecting from the 7 options: ‘anger’, ‘disgust’, ‘fear’, ‘happiness’, ‘sadness’, ‘surprise’, or ‘neutral’. Participants were instructed to respond as quickly and accurately as possible, but a maximum 10 seconds was given to respond. Any response outside this time was deemed to be unrepresentative for the current affect categorization task (see Hurley, 2012; Hurley et al., 2014). After the participant’s response, a 500 ms blank screen inter-trial interval was presented.

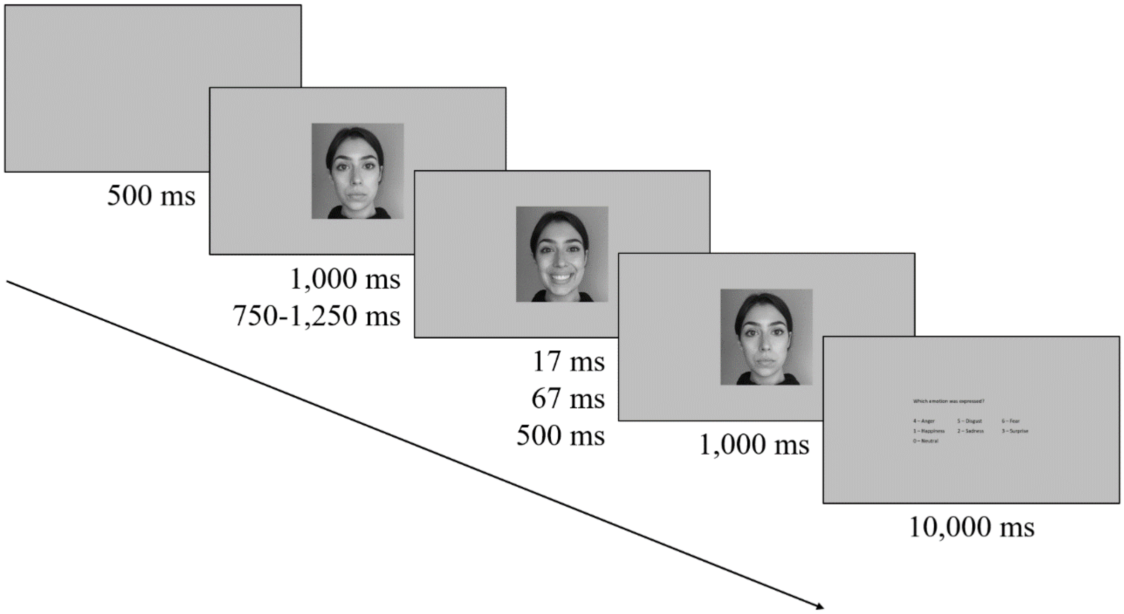
All stimuli were presented as 600 by 625 pixel grey-scaled images in the center of the monitor. In addition, expressions of emotion were aligned with their neutral face counterparts using the dorsum of the nose, which offered a more stable baseline across the various expressions. There was a total of 216 trials, with 3 target presentation durations (17, 67, and 500 ms), 6 target expressions of emotion (Anger, Disgust, Fear, Happiness, Sadness, and Surprise), 4 models (2 male, 2 female), and 3 repetitions. Trials were presented in random order.

Data Analyses

Using R (version 3.6.1) software, participant responses were transformed into binary values to compute hit rates—responses that aligned with an expression’s expected label—and erroneous response rates—responses that did not align with an expression’s expected label. That is, when calculating hit rates, a “1” was given when a response corresponded with the image’s expected emotional label, while a “0” was given when it did not. Conversely, when calculating the 6 erroneous response rates for each target expression, a “1” was only given to an emotional response option when that response was used and it did not correspond with the image’s expected emotional label, while a “0” was used for all other cases.

Figure 1

Sequence of Events Presented Within a Single Trial for Both Forward-Mask Condition Groups (Fixed: 1,000 ms; Variable: 750 – 1,250 ms) and the Target Durations (17, 67, and 500 ms).



To approximate the necessity threshold for each target expression, each group's hit rates were compared to chance (1/6 or 16.67%) using single-sample t-tests—accounting for target emotion and duration. Bonferroni adjustments were applied to *p* values to account for the multiple comparisons. Next, to explore the efficiency threshold, hit rates were compared across conditions in a 6 (Target Emotion: Anger, Disgust, Fear, Happiness, Sadness, and Surprise) x 3 (Target Duration: 17, 67, and 500 ms) x 2 (Forward Mask: fixed-duration or variable-duration) mixed-design ANOVA. Greenhouse-Geisser corrections were applied where the assumption of sphericity was violated according to Mauchley's test, and Bonferonni adjustments were applied for all post-hoc comparisons.

Task performance was further examined through an analysis of erroneous response rates. These were analyzed in two stages: (1) chi-squared goodness-of-fit tests were used to determine if participants used any particular erroneous response more than others [expected erroneous rate = (1 – hit rate) / 6] and (2) Where the chi square test showed non-uniform use of erroneous response options, all erroneous response rates were compared to chance (16.67%) in single-sample t-tests. Bonferroni adjustments were applied to *p* values to account for the multiple comparisons.

Results and Discussion

The JACBART was designed as a standardized approach for testing one's ability to recognize brief displays of emotion. This paradigm displays a target expression of emotion between presentations of two neutral expression images of the same actor. The neutral face image appearing before the target image is referred to as the forward mask, whereas the one appearing after is called the backward mask (Matsumoto et al., 2000). While there has been some work on the effects of the backward mask, there is currently little research exploring the influence of the forward mask on performance in the JACBART (Esteves & Öhman, 1993; Macknik & Livingstone, 1998). In addition, previous studies examining the categorization of briefly presented facial expression images have generally examined only a limited range of expressions (e.g., Esteves & Öhman, 1993; Milders et al., 2008; Pessoa et al., 2005) or have not analyzed differences across the expression categories (e.g., Calvo & Lundqvist, 2008).

With this in mind, the current study was designed to explore the role of the forward mask's duration, specifically the effects of changing from a fixed duration (1,000 ms) to a variable one (750 – 1,250 ms), on the categorization of briefly-presented facial expressions of emotion. In addition, it sought to explore the influence of the forward mask's duration on the necessity threshold—defined as the minimum target duration required to exceed chance—and efficiency threshold—defined as the point where target recognition is no longer benefitted by longer display times. To this end, using the JACBART design, three target expression durations—17, 67, and 500 ms—were used to present expressions of six basic emotions: Anger, Disgust, Fear, Happiness, Sadness, and Surprise. Current findings did not demonstrate a significant effect or interaction with the forward mask's duration (see Table 1). Conversely, a significant interaction was observed between target emotion and target duration. Results for each emotion will be discussed in turn.

Table 1

Mixed-Design ANOVA Examining Hit Rate Differences Across the Forward Mask Conditions, Target Emotions, and Target Durations.

	df	*F*	η_G^2
Forward Mask	1, 28	0.08	0.0007
Target Emotion	3.52, 98.62	111.80 ***	0.56
Forward Mask * Target Emotion	2, 56	0.94	0.01
Target Duration	3.52, 98.62	277.30 ***	0.59
Forward Mask * Target Duration	2, 56	1.82	0.01
Target Emotion * Target Duration	6.03, 168.87	36.19 ***	0.27
Forward Mask * Target Emotion * Target Duration	6.03, 168.87	1.16	0.01

† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

Anger Expressions

Our findings showed that with expressions of anger, in contrast to prior literature (Milders et al., 2008; Pessoa et al., 2005), 17 ms was not sufficient for expression categorization; Hit rates were not observed to exceed chance with either the fixed-duration or variable-duration forward masks (see Table 2 and 3). Indeed, angry expressions were often erroneously recognized as 'neutral' with this target duration—regardless of the forward mask condition (see Table 2 and 3). This disparity from the findings of Milders and colleagues (2008) was not initially hypothesized but may be due to differences in methodology. Specifically, Milders and colleagues used a different expressor identities for the mask and target images, whereas the current design used the same expressor identity for both. As Milders et al. themselves show, the type of mask can impact performance. They observed that a neutral face mask increased the task difficult relative to a dynamic checkerboard mask. Our results can be seen as an extension of theirs, showing that when a same-identity face is used as a forward mask, it reduces performance compared to a different-identity face. This in turn means that more time is required to recognize a facial expression when a same-identity face is used as a mask.

Correct categorization of angry face images improved with durations longer than 17 ms (both $p < .001$). The ‘anger’ response was used at a rate above chance with both the 67 and 500 ms displays of angry expressions regardless of the forward mask duration condition (see Table 2 and 3). Also, there was no significant difference between the anger hit rates with these two longer target durations ($p = .06$; see Table 1 and Figure 2). Contrary to the findings of Calvo and Lundqvist (2008), this suggests anger may be efficiently recognized with as little as a 67 ms expression display time. However, inconsistent with prior literature (Gagnon et al., 2010; Gosselin et al., 1995; Jack et al., 2009), expressions of anger were categorized with the ‘disgust’ option at rates above chance.

Table 2

Mean Hit Rates and Erroneous Response Rates (Standard Error) for the Fixed-Duration Forward Mask Group (n = 13). Including Chi-Square Goodness-of-Fit Tests (df = 5) and Single-Sample T-Tests (Chance = 16.67%).

Target Duration	χ2	Response Rates						
		Anger	Disgust	Fear	Happiness	Sadness	Surprise	Neutral
				Expressions of Anger				
17	211.54^{***}	0.09 (0.03)	0.10 (0.04)	0.01 (0.01)	0.04 (0.03)	0.05 (0.02)	0.03 (0.02)	0.67 (0.10)**
67	45.09^{***}	0.48 (0.08)*	0.24 (0.04)	0.03 (0.02)	--	0.11 (0.03)	0.02 (0.01)	0.12 (0.05)
500	140.47^{***}	0.51 (0.09)*	0.38 (0.09)	0.02 (0.01)	--	0.06 (0.03)	--	0.01 (0.01)
				Expressions of Disgust				
17	87.60^{***}	0.14 (0.05)	0.29 (0.06)	0.03 (0.02)	0.08 (0.04)	0.03 (0.01)	0.03 (0.02)	0.40 (0.09)
67	96.63^{***}	0.31 (0.09)	0.56 (0.08)**	0.03 (0.02)	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)	0.05 (0.03)
500	29.10^{***}	0.08 (0.03)	0.87 (0.04)***	0.04 (0.03)	--	--	--	--
				Expressions of Fear				
17	109.73^{***}	0.01 (0.01)	0.05 (0.02)	0.13 (0.05)	0.03 (0.01)	0.03 (0.02)	0.28 (0.07)	0.45 (0.11)
67	76.90^{***}	--	0.06 (0.03)	0.54 (0.06)***	0.01 (0.01)	--	0.28 (0.05)	0.09 (0.05)
500	21.97^{***}	--	0.03 (0.02)	0.86 (0.05)***	--	0.01 (0.01)	0.08 (0.04)	0.01 (0.01)
				Expressions of Happiness				
17	43.01^{***}	--	0.01 (0.01)	0.01 (0.01)	0.84 (0.05)***	--	0.01 (0.01)	0.13 (0.04)
67	4.49	0.01 (0.01)	0.01 (0.01)	--	0.96 (0.02)***	--	--	0.02 (0.01)
500	3.21	--	--	--	0.99 (0.01)***	--	--	0.01 (0.01)
				Expressions of Sadness				
17	251.46^{***}	0.03 (0.01)	0.04 (0.03)	0.02 (0.01)	0.01 (0.01)	0.16 (0.06)	0.05 (0.03)	0.68 (0.10)**
67	35.69^{***}	0.07 (0.03)	0.07 (0.03)	0.03 (0.02)	--	0.62 (0.07)**	0.02 (0.01)	0.19 (0.06)
500	$10.35^{\dagger}$	--	0.03 (0.03)	0.01 (0.01)	--	0.96 (0.03)***	0.01 (0.01)	--
				Expressions of Surprise				
17	58.29^{***}	--	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.82 (0.06)***	0.15 (0.06)
67	7.69	--	--	0.02 (0.01)	--	--	0.96 (0.02)***	0.02 (0.01)
500	$9.62^{\dagger}$	--	--	0.02 (0.01)	--	--	0.98 (0.01)***	--

*** $p < .001$; ** $p < .01$; * $p < .05$; † $p < .10$; one-tailed; Bonferroni adjusted

Table 3

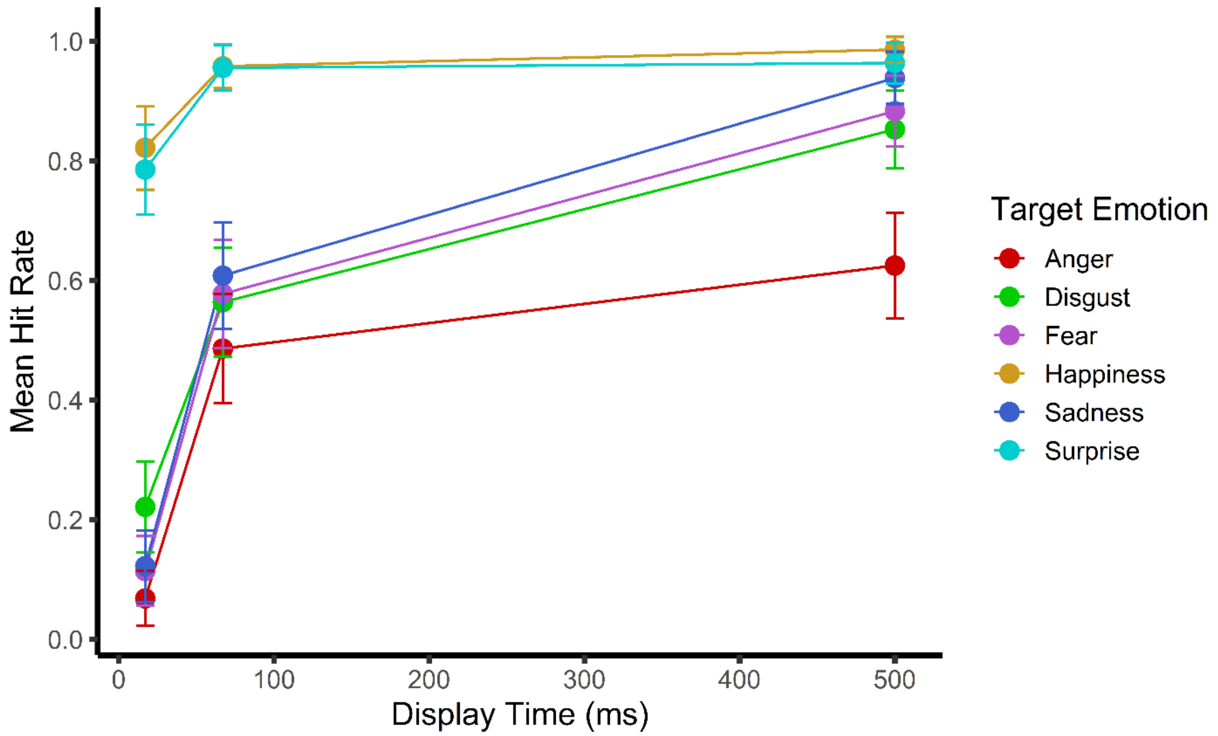
Mean Hit Rates and Erroneous Response Rates (Standard Error) for the Variable-Duration Forward Mask Group (n = 17). Including Chi-Square Goodness-of-Fit Tests (df = 5) and Single-Sample T-Tests (Chance = 16.67%).

Target Duration	$\chi 2$	Response Rates						
		Anger	Disgust	Fear	Happiness	Sadness	Surprise	Neutral
				Expressions of Anger				
17	287.68***	0.05 (0.02)	0.05 (0.02)	0.02 (0.01)	0.03 (0.02)	0.04 (0.02)	0.03 (0.02)	0.77 (0.08)***
67	39.67***	0.49 (0.05)***	0.23 (0.04)	0.04 (0.02)	0.00 (0.00)	0.10 (0.02)	0.01 (0.01)	0.11 (0.03)
500	49.49***	0.71 (0.05)***	0.18 (0.05)	0.02 (0.02)	--	0.05 (0.02)	0.01 (0.01)	0.01 (0.01)
				Expressions of Disgust				
17	65.81***	0.13 (0.04)	0.17 (0.04)	0.05 (0.02)	0.12 (0.03)	0.02 (0.01)	0.08 (0.03)	0.40 (0.06)*
67	76.58***	0.28 (0.06)	0.57 (0.06)***	0.04 (0.01)	0.03 (0.01)	0.00 (0.00)	0.03 (0.02)	0.04 (0.03)
500	25.80***	0.10 (0.03)	0.84 (0.05)***	0.03 (0.01)	--	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)
				Expressions of Fear				
17	148.98***	0.02 (0.01)	0.03 (0.02)	0.10 (0.02)	0.05 (0.02)	0.02 (0.01)	0.25 (0.07)	0.53 (0.07)***
67	95.33***	0.02 (0.02)	0.01 (0.01)	0.60 (0.05)***	0.03 (0.01)	--	0.29 (0.05)	0.03 (0.02)
500	18.73**	--	0.02 (0.02)	0.90 (0.02)***	--	0.01 (0.01)	0.06 (0.02)	--
				Expressions of Happiness				
17	12.65*	0.01 (0.01)	--	0.03 (0.01)	0.81 (0.04)***	0.01 (0.01)	0.06 (0.02)	0.07 (0.03)
67	2.45	0.01 (0.01)	0.01 (0.01)	--	0.96 (0.02)***	--	0.01 (0.01)	0.00 (0.00)
500	1.23	--	0.00 (0.00)	--	0.98 (0.01)***	--	0.00 (0.00)	0.00 (0.00)
				Expressions of Sadness				
17	314.79***	0.01 (0.01)	0.05 (0.02)	--	0.00 (0.00)	0.09 (0.03)	0.05 (0.03)	0.78 (0.08)***
67	48.27***	0.04 (0.02)	0.08 (0.03)	0.03 (0.02)	--	0.60 (0.07)***	0.02 (0.01)	0.22 (0.06)
500	8.92	--	0.03 (0.03)	0.02 (0.01)	--	0.93 (0.04)***	0.01 (0.01)	--
				Expressions of Surprise				
17	41.04***	0.01 (0.01)	--	0.04 (0.02)	0.01 (0.01)	0.02 (0.01)	0.76 (0.05)***	0.15 (0.04)
67	8.63	--	--	0.03 (0.02)	0.01 (0.01)	0.00 (0.00)	0.95 (0.02)***	--
500	14.51*	--	--	0.04 (0.02)	0.00 (0.00)	0.00 (0.00)	0.95 (0.02)***	--

*** p < .001; ** p < .01; * p < .05; † p < .10; one-tailed; Bonferroni adjusted

Figure 2

Mean Hit Rates for the Various Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Durations (17, 67, and 500 ms), with Combined Forward-Mask Condition Groups (Fixed and Variable).



Disgust Expressions

With expressions of disgust, 17 ms was not always sufficient for correct categorization; the ‘disgust’ response option was not used at a rate exceeding chance regardless of the forward mask condition. Indeed, participants often erroneously labelled these brief expressions as ‘neutral’, regardless of the forward mask condition (see Table 2 and 3). Consistent with Calvo and Lundqvist (2008), longer display times consistently improved proper ‘disgust’ response rates—regardless of the forward mask condition (all $p < .001$; see Table 1 and Figure 2). However, inconsistent with Calvo and Lundqvist (2008), 67 ms was sufficient for proper disgust categorization to exceed chance.

Fear Expressions

A 17 ms presentation duration was not sufficient for participants to categorize this expression as ‘fear’ at a rate above chance (see Tables 2 and 3). Instead, this expression often resulted in an erroneous usage of the ‘neutral’ response when presented with a variable-duration forward mask. Hit rates were once again observed to improve with longer expression display times (all $p < .001$; see Table 1 and Figure 2), and fear expressions were properly labelled at rates above chance with both the 67 and 500 ms display times. However, inconsistent with prior literature (Chamberland et al., 2017; Gagnon et al., 2010; Gosselin et al., 1995; Gosselin & Simard, 1999; Jack et al., 2009; Roy-Charland et al., 2014; Roy-Charland et al., 2015), fear expressions were not confused with ‘surprise’ after corrections for multiple comparisons.

Happiness Expressions

Contrary to the expressions of emotion discussed above, but consistent with prior literature (Milders et al., 2008), 17 ms was sufficient for happy expressions to be accurately labelled with the ‘happy’ response at a rate above chance. In addition, participants did not present any biases in their erroneous response options when presented with expressions of happiness (see Table 2 and 3). Accurate ‘happy’ response rates consistently improved as participants were presented with the happy expression for longer durations (all $p \leq .05$; see Table 1 and Figure 2)—regardless of the forward mask condition.

Sadness Expressions

With the 17 ms display time, facial expressions of sadness were not accurately categorized (i.e., the ‘sadness’ response option was not used) at rates above chance—regardless of the forward mask condition—and were, instead, erroneously labelled as ‘neutral’ at rates above chance (see Table 2 and 3). Findings show that these categorization rates improved with longer display times (all $p < .001$; see Table 1 and Figure 2), and the ‘sadness’ label was correctly used at rates above chance with the 67 and 500 ms display durations. In addition, chi-square goodness-of-fit tests indicate there was no bias for any particular erroneous response option with the longer display time (500 ms; Table 2 and 3).

Surprise Expressions

As with expressions of happiness, 17 ms was sufficient for the correct categorization of surprise. Indeed, expressions of surprise were recognized at rates above chance regardless of forward mask variability condition or display time. In addition, participants did not present a bias for any particular erroneous response (see Tables 2 and 3). Despite the observed high hit rates with this expression, the ‘surprise’ response was still accurately used at greater rates with the 67 and 500 ms display times than the 17 ms display time (both $p < .001$). However, no significant difference was observed between the two longer display times ($p > .99$; see Figure 2).

Limitations and Future Directions

The current study was exploratory in nature with regards to the categorization thresholds and was not intended to determine precise measures of the defined thresholds. Instead, the purpose was to use these thresholds to explore the role of the forward mask’s duration. Results nevertheless offer further insight and demonstrate how, in a JACBART paradigm, these thresholds can vary across facial expressions of emotion. Further research employing more presentation times will be needed to determine precise stimulus duration thresholds.

Future research may want to further explore the role of a variable-duration forward mask with shorter target presentation times. However, as it is uncommon with the JACBART and biologically impossible for a micro-expression to be presented for such brief durations, said research is not entirely warranted. It should also be noted that, although the current design presented a range of forward mask variability not previously observed with the JACBART, further research is needed to determine if a wider range of variability could have a greater effect.

Conclusion

In sum, our findings suggest the forward mask manipulation did not significantly affect categorization rates. Nevertheless, the temporal dynamics of affect categorization were observed to vary across the six basic emotions. Specifically, although 17 ms was sufficient for the categorization of expressions of happiness and surprise, a minimum of 67 ms was necessary for expressions of anger, disgust, fear, and sadness—consequently suggesting the necessity threshold could be below 17 ms with expressions of happiness and surprise, but somewhere between 17 and 67 ms with expressions of anger, disgust, fear, and sadness. Finally, 67 ms was not sufficient for efficient brief affect categorization with expressions of disgust, fear, happiness, or sadness, and the efficiency threshold is suggested to fall somewhere between 67 and 500 ms. Conversely, a relatively shorter efficiency threshold is suggested to fall between 17 and 67 ms for expressions of anger and surprise—as 67 ms was sufficient for efficient categorization rates. These data show the necessity of considering which expressions of emotion one is examining when considering the speed with which individuals can recognize them. In addition, they help to bracket the durations needed to categorize a range of common expression types.

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Study 2

Brief Affect Recognition Task Considerations: The Role of a Neutral Response Option in the Japanese and Caucasian Brief Affect Recognition Task

Abstract

Micro-expressions are proposed to be brief expressions that represent the expressor's true states of emotion. As such, their correct recognition can be especially important. The current study applied a psychophysical approach to assess the recognition of brief facial expressions of emotion in a Japanese and Caucasian Brief Affect Recognition Task (JACBART) paradigm with or without a 'neutral' response option. It was hypothesized that the presentation of a 'neutral' option would reduce guessing behaviours and subsequently reduce task hit rates and task performance. The addition of this response option was indeed observed to negatively impact task performance with the shorter display durations (i.e., 40 ms and less). However, the effect was not consistent across all emotions, in that recognition performance for expressions of anger and fear was unaffected by the presence or absence of the 'neutral' response option. Future administration of the JACBART should therefore consider display duration when determining whether to include a 'neutral' option. Although it may increase ecological validity, its inclusion may complicate interpretations with very short display durations.

Brief Affect Recognition Task Considerations: The Role of a Neutral Response Option in the Japanese and Caucasian Brief Affect Recognition Task

The ability to accurately understand emotions in others through facial expression recognition is often deemed an important ability in high-stakes situations (ten Brinke et al., 2012; Porter & ten Brinke, 2010). This ability is however complicated by the efficiency humans demonstrate in controlling their own facial muscles through simulation, inhibition, and masking expressions (Ekman, 1985/2009; Ekman & Friesen, 1969; Zuckerman et al., 1981). It can therefore be beneficial, in terms of determining what others are truly feeling, that this control is not absolute. For instance, when an individual attempts to inhibit and conceal the expression of a felt emotion, an expression of said emotion may at times leak through the individual's control and present itself for a brief duration (Ekman & Friesen, 1969, 1974; Haggard & Isaacs, 1966; Rinn, 1984, 1991; Matsumoto & Lee, 1993). These brief displays of the true emotion are often referred to as micro-expressions and conceptually differ from uninhibited facial expressions of emotion that are typically presented for between 500 and 4,000 ms (i.e., macro-expressions; Frank et al., 1993). Indeed, although there are inconsistencies in the literature (Ekman, 1985/2009; Frank et al., 1993; Porter & ten Brinke, 2008; Porter et al., 2012; Yan et al., 2013), micro-expressions are generally understood to be presented for durations as short as 40 ms and as long as 500 ms (Frank et al., 1993; Paul Ekman Group, n.d.; Matsumoto & Hwang, 2018; Yan et al., 2013).

The increased capability to discern the genuine emotions of others makes the accurate recognition of micro-expressions a valuable ability for detecting lies (Matsumoto & Hwang, 2018) and has led to a great deal of research exploring whether this ability can be learned (Hurley, 2012; Hurley et al., 2014; Marsh et al., 2010; Matsumoto & Hwang, 2014; Matsumoto et al., 2014; Porter et al., 2010; Russel et al., 2006, 2008). Nevertheless, there is limited empirical research exploring the design parameters that influence the limits of this ability.

Experiments using the Brief Affect Recognition Test (i.e., BART; Ekman & Friesen, 1969)—where an expression of emotion is simply presented for a brief duration and the observer is asked to categorize the displayed emotion—have demonstrated that increases in display duration are generally beneficial to the accurate recognition of emotion (Calvo & Lundqvist, 2008; Shen et al., 2012). However, these benefits are not consistent across different emotions (e.g., Kirouac & Doré, 1984; Shen et al., 2012). High recognition performances have for instance been observed to asymptote with very brief expressions of happiness, while more time is generally needed for other expressions. Due to inconsistencies in methodology and analysis in the literature, however, it is not possible to determine the point at which performance plateaus for each emotion (i.e., the maximum useful stimulus duration). For instance, Kirouac and Doré (1984) only explored these differences across emotions with display durations of 50 ms or less. Conversely, Calvo and Lundqvist (2008) and Shen et al. (2012) both failed to examine the different effects of display duration across emotions despite finding a significant interaction between presentation time and expression of emotion category.

Interpretations of these previous works are further complicated by inconsistencies in methodology. For instance, studies use various sorts of backward masks, which are images that appear immediately after the stimulus image to interfere with post-offset processing. Some studies have used no backward mask, while others have used a mask consisting of 1) A checkerboard pattern, 2) A neutral version of a face whose identity is different from that of the target image, or 3) A neutral version of a face whose identity is the same as that of the target image. Findings show that brief affect recognition rates are negatively impacted by the presentation of a backward mask of at least 30 ms following the target expression of emotion (Esteves & Ohman, 1993). This is especially true with shorter target expression durations (i.e., less than 120 ms; Shen et al., 2012). Milders and colleagues (2008) also demonstrated that increased target-mask morphological similarity further increases recognition difficulty. Thus it is impossible to directly compare results across studies using these different masking procedures.

Taken together, these studies demonstrate the importance of the Japanese and Caucasian Brief Affect Recognition Task (i.e., JACBART; Matsumoto et al., 2000) design—where a target expression of emotion is briefly displayed between two neutral expressions (i.e., a forward and backward mask). Unlike some backward mask design studies (e.g., Esteves and Ohman, 1993; Milders et al., 2008), the JACBART method uses same actor for both the masks and target within a trial. Due to increased morphological similarity between mask and target, this would be expected to further increase task difficulty (Milders et al., 2008). Indeed, with shorter target expression durations, the JACBART design would theoretically function as both a discrimination task and a recognition task—where the observer must first detect the target by discriminating it from the masks then recognize the target expression category. As such, this dual-task design brings to question whether individuals can subliminally recognize the target expression despite discrimination difficulties. For instance, Russell (1994) demonstrated that humans are intelligent decoders that will use the information at their disposal to strategically categorize expressions of emotion when the response option is unclear. It is therefore conceivable for individuals to accurately “guess” an emotion category more often than not even when they report that they have not detected an expression of emotion of any sort.

A psychophysical approach was adopted for the current study to explore affect recognition performance in a JACBART design. This included a 6-alternative forced choice

(6AFC) task with six target expressions (anger, disgust, fear, happiness, sadness, and surprise) and the six response options. Using a similar design, Shen and colleagues (2012) demonstrated that respondents are generally capable of recognizing brief affect expressions at rates above chance with as little as 20 ms. Individuals in their study were however trained to correctly label each target expression before measuring brief affect recognition capabilities. Although this would theoretically reduce the error resulting from expression unfamiliarity, it also reduces the ecological validity of the measure. As it is unlikely for an individual to know with absolute certainty the category of a specific expression configuration in a real-life scenario, it is important to understand how well individuals would perform without image training. In addition, it is also important to understand the psychometric function thresholds with this 6AFC task.

A common JACBART paradigm was also explored, where a 'none of the above' or 'neutral' response option is additionally presented (e.g., Chamberland & Collin, 2022; Hurley, 2012; Hurley et al., 2014; Matsumoto & Hwang, 2011)—henceforth referred to as the *modified 6AFC*. It is proposed that this paradigm is useful because it prevents artifactual agreement (Frank & Stennett, 2001). As such, by instructing respondents to use the 'neutral' response option to indicate they did not detect an expression of emotion between the two neutral masks, respondents should only use the emotion response options when they feel capable discriminating the target expression from the masks. Limited research has explored this paradigm with brief target durations. Performance rates and psychometric function thresholds are therefore unclear with this modified 6AFC design. It is however hypothesized that this paradigm will reduce the 'guessing' behaviours resulting from discrimination and detection difficulties, whereby performances with shorter target durations are reduced compared to the standard 6AFC. Conversely, differences between the two paradigms are not anticipated with the longer target durations—as discrimination and detection difficulties are hypothesized to have little to no affect with these durations.

To further understand potential effects of participants' response biases, DeCarlo's (2012) *biased d*' estimates were calculated and compared to d' measures that assume no bias (i.e., *unbiased d'*). Although it is commonly assumed that respondents will not present strategic biases in an mAFC task (Hautus et al., 2021), the modified 6AFC was hypothesized to present a bias for the 'neutral' response with shorter target durations. According to DeCarlo (2012), this response bias would be demonstrated by elevated biased *d*' estimates—calculated by accounting for response biases—when compared to unbiased *d*' estimates—calculated without accounting for response biases. Conversely, as it is commonly assumed that significant response biases are not observed in an mAFC task, a significant difference was not anticipated between biased and unbiased *d*' estimates for the current 6AFC.

Methods

Participants

Sixty participants in total were recruited for the current experiment using the University of Ottawa's Integrated System of Participation in Research (ISPR) student pool. Upon arrival, participants were pseudo-randomly assigned to either the Standard 6AFC group (6 males and 24 females; $M_{Age} = 19.30$, $SD = 2.09$) or the Modified 6AFC group (3 males and 27 females; $M_{Age} = 18.27$, $SD = 1.23$). These group assignments determined the response options presented to participants. Specifically, those in the Standard 6AFC group were not presented with a 'neutral' response option, while those in the Modified 6AFC group did have a 'neutral' response option available (i.e, in addition to the standard responses of 'anger', 'disgust', 'fear', 'happiness', 'sadness', and 'surprise').

Materials

A total of 28 images were taken from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE), Standard Version (Matsumoto & Ekman, 1988), a validated database of images showing facial expressions (Biehl et al., 1997). Images of two male (JC and SW1) and two female (MM and NH1) models portraying six expressions of emotion (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) were used. In addition, images showing each of the models with a neutral expression were used as forward and backward masks in the JACBART paradigm. Expressions of emotion were then centered to their neutral expression counterparts using the nasion and cropped to have a pixel dimension of 600 by 625 (72 dpi). Further, to reduce colour noise in the JACBART paradigm, all images were colour matched in MATLAB and gray-scaled. Finally, images were luminance corrected in MATLAB by ensuring that the mean and RMS of pixel values in each image were the same as the overall mean and RMS for all images.

For both groups, the experiment was run using the Psychophysics Toolbox extension (Brainard, 1997; Pelli, 1997; Kleiner, Brainard, & Pelli, 2007) on MATLAB R2019a (The Math Works, Inc., 2019), with a Linux operating system. This was done using a 24.5” ASUS ROG Swift PG258Q monitor operating at a 200 Hz frame rate and a 1920 by 1080 resolution. In addition, all images and text were displayed on a medium gray background (RGB: 127, 127, 127) to reduce eyestrain.

Procedure

The current experiment used the JACBART to measure emotion recognition. In this task, target expressions were presented for durations of 5, 10, 20, 40, 80, 160, or 500 ms (i.e., 1, 2, 4, 8, 16, 32, or 100 frames at 200 Hz). Each expression was presented between two neutral face masks having the same identity as the target face. The duration of the forward mask was varied from 750-1250 ms (with 5 ms increments), while the backward mask’s duration was held constant at 1000 ms. The duration of the forward mask was varied in order to reduce the risk of anticipatory responses. After each trial, participants were instructed to indicate “which emotion was expressed” between the two neutral faces using their keyboard. Six response options were offered to the Standard 6AFC group: ‘anger’, ‘disgust’, ‘fear’, ‘happiness’, ‘sadness’, and ‘surprise’. Meanwhile, the Modified 6AFC group was presented these same six response options and the option to label the expression as ‘neutral’ if they felt they did not see an emotion during the trial. Finally, a 500 ms inter-trial blank screen was presented following the participant’s response.

Each participant began with a brief practice block to familiarize them with this task. The practice block presented each of the seven target durations at least once, with the expression of emotion and identity for each presentation selected randomly. Once ready, participants began the experimental phase. In total, 672 experimental trials were randomly presented with the 6 target expressions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise), 7 target durations (5, 10, 20, 40, 80, 160, and 500 ms), 4 face identities per expression, and 4 repetitions per image. In addition, to ensure the accuracy of the target durations, a protocol was put in place to flag and re-integrate any trials that did not meet the intended target duration. In other words, if a target trial was intended to be presented for 5 ms (1 frame) but was instead presented for 10 ms (2 frames), that trial would be run again at the end of the experiment. However, results indicated that this protocol was not triggered at any time during the study, meaning that the target expressions were always presented for the correct duration. Finally, participants were offered a break every 100 trials to reduce fatigue.

Results

Data was processed using R version 3.6.1 (R Core Team, 2019). Response data were converted to binary information representing the categorical response option (‘anger’, ‘disgust’, ‘fear’, ‘happiness’, ‘sadness’, ‘surprise’, or ‘neutral’) used for each trial, with ‘1’ and ‘0’ respectively indicating whether the response option was or was not used for the trial (see Supplemental Table 1 and 2). These values were then used to calculate hit rates with ‘1’ indicating the response was consistent with the intended alternative (e.g., ‘anger’ for an angry expression; i.e., a hit) and ‘0’ indicating the response was not consistent with the intended alternative (e.g., ‘disgust’ for an angry expression; i.e., a miss). These hit rates were subsequently used to calculate two measures of sensitivity, termed unbiased d′ and biased d′, where the observer is respectively assumed to be unbiased or biased towards one or more response categories (DeCarlo, 2012; Hautus et al., 2021). These estimates were divided by a factor of 1.28 to account for the increased scaling employed by logit models ($\sqrt{\pi^2/6} \approx 1.28$), as compared to probit models (Train, 2003/2009/2014). Greenhouse-Geisser corrections were applied where the sphericity assumption was violated within any ANOVAs. Subsequent post-hoc t-test analyses were implemented with Bonferroni corrections.

Hit Rates

For hit rates, a 2 (Response Options Group: Standard 6AFC or Modified 6AFC) x 6 (Target Emotion: Anger, Disgust, Fear, Happiness, Sadness, and Surprise) x 7 (Target Duration: 5, 10, 20, 40, 80, 160, 500 ms) mixed-design ANOVA was used to explore differences across conditions. This included target emotion and target duration as within-subject variables, and response options group as a between-subject variable. Results indicate there were significant main effects for the response options group, target emotion, and target duration variables (see

Table 1). In addition, the target duration significantly interacted with both response option group and target emotion in two-way interactions. Conversely, the interaction between response options group and target emotion was not significant. Finally, there was a significant higher-order interaction between all three variables.

Table 1

Hit Rate Mixed-Design ANOVAs with Response Options Group (Standard 6AFC vs. Modified 6AFC), Target Emotion (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Target Duration (5, 10, 20, 40, 80, 160, and 500 ms).

	df	*F*	η^2_G
Neutral Response	1, 58	20.92 ***	0.09
Target Emotion	3.87, 224.69	199.73 ***	0.44
Target Duration	2.62, 152.04	1245.66 ***	0.70
Neutral Response × Target Emotion	3.87, 224.69	1.22	
Neutral Response × Target Duration	2.62, 152.04	22.83 ***	0.04
Target Emotion × Target Duration	9.56, 554.36	35.11 ***	0.19
Neutral Response × Target Emotion × Target Duration	9.56, 554.36	2.68 **	0.02

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Simple effect analyses for the higher-order interaction were conducted independently for each target emotion. That is, a 2-way mixed ANOVA was run for each of the 6 target emotions with Target Duration (within subjects) and Response Options Group (between subjects) as factors. For expressions of anger and fear, the neutral response did not have a significant effect or interaction with target duration. However, for angry and fearful expressions, target duration was observed to have a significant effect such that hit rates continuously improved with longer target display durations after 10 ms, with the exception that the difference between 80 and 160 ms conditions was not significant for anger (i.e., for Anger: 5 = 10 < 20 < 40 < 80 = 160 < 500; for Fear: 5 = 10 < 20 < 40 < 80 < 160 < 500). For all remaining target emotions, there were significant interactions between response option groups and target duration. For expressions of disgust and sadness, the presence of a ‘neutral’ response option resulted in significantly lower hit rates for these target expressions at 5, 10, 20, and 40 ms presentation durations, when compared to equivalent conditions without said response option. Conversely, the availability of a ‘neutral’ response did not have a significant effect with target durations of 80, 160 and 500 ms. For expressions of happiness, the ‘neutral’ response resulted in significantly lower hit rates—when compared to those without the ‘neutral’ response—with target durations of 10 ms and less, while target durations of 20 ms and more presented no such significant difference. Finally, a significant difference between the neutral response groups was observed with target durations of 20 ms and less for expressions of surprise, but no such difference was observed with target durations of 40 ms and more.

Psychometric Functions

The theoretical psychometric function for a 6AFC task ranges from chance (≈ 0.17) to perfect recognition (1.00). However, examination of the data (see Figure 1) demonstrated that performance maxima and minima varied from these theoretical limits to different degrees depending on the experimental condition. As such, any psychometric function bound to the basic theoretical performance limits would be expected to have reduced fit (see Supplemental Table 3). The ‘psyfun.2asym’ function (Knoblauch, 2014) was therefore used to fit logit models to the hit rate data, which estimates best fitting upper ($1-\lambda$) and lower (γ) asymptotes in addition to intercept (β_0) and slope (β_1) estimates. Resulting psychometric functions are presented in Figure 1 and referenced to the theoretical threshold for a 6AFC task (≈ .58). Meanwhile, observed fit estimates can be observed in Table 2. The observed threshold, its location, and function’s scale can be calculated from these obtained values (see Table 2; Knoblauch & Maloney, 2012).

Minimum Presentation Times Required to Exceed Chance Level Performance

Hit rates were also compared to chance using one-tailed single-sample t-tests, with chance set to 0.17 (= 1/6) for both groups (see Figure 1 and Supplemental Table 1 and 2). When a 'neutral' response was not provided, results indicate hit rates exceeded chance when angry expressions were presented for at least 20 ms. Conversely, a minimum of 40 ms was needed when a 'neutral' response was provided. Although hit rates exceeded chance when expressions of disgust and sadness were presented for as little as 5 ms without a 'neutral' response, a minimum 40 ms was needed when the participant was provided with a 'neutral' response alternative. Conversely, with or without a 'neutral' response, hit rates exceeded chance with 20 ms expressions of fear, while only 5 ms was needed with expressions of happiness and surprise.

Table 2

Psychometric Function Parameters for the Logit Models, Including the Observed Performance Threshold, Location of the Threshold (ms), Scale of the Linear Continuum, Intercept (β_0), Slope (β_1), Lambda (λ), and Gamma (γ).

Neutral	Emotion	Threshold	Location	Scale	β_0	β_1	λ	γ
Without	Anger	0.44	37.06	0.64	-4.55	1.57	0.23	0.11
	Disgust	0.50	22.82	0.94	-2.32	1.06	0.15	0.16
	Fear	0.50	27.89	0.84	-2.96	1.19	0.08	0.08
	Happiness	0.49	4.90	1.07	0.03	0.94	0.01	< 0.01
	Sadness	0.64	50.98	0.48	-6.92	2.06	0.05	0.32
	Surprise	0.72	11.73	0.40	-3.06	2.49	0.04	0.48
With	Anger	0.35	39.18	0.38	-7.92	2.66	0.32	0.01
	Disgust	0.43	40.00	1.02	-2.95	0.98	0.14	< 0.01
	Fear	0.44	34.58	0.72	-3.88	1.39	0.12	< 0.01
	Happiness	0.49	8.83	0.81	-1.01	1.23	0.03	< 0.01
	Sadness	0.50	45.63	0.45	-7.13	2.23	0.05	0.05
	Surprise	0.58	13.47	0.48	-2.96	2.07	0.06	0.22

Sensitivity

In line with DeCarlo (2012), sensitivity (*d'*) was estimated by conducting multinomial logit models through the 'gmnl' function in R (Sarrias & Daziano, 2017). By either including or excluding response rate data in the model, this approach can calculate *d'* values that respectively assume the observer is either biased or unbiased. In addition, through the biased response models, this approach provides choice bias estimates relative to a baseline response option. As shown in Figure 2, an examination of solely the unbiased *d'* estimates would suggest individuals are less sensitive in the affect classification task with 5 to 40 ms target durations when they are presented with a ‘neutral’ response than when they are not. However, when response biases are taken into consideration, *d’* estimates significantly increase with the target durations from 5 to 40 ms. As demonstrated by DeCarlo (2012), this increase is indicative of a significant response bias with these target durations when the observers had a ‘neutral’ response. Conversely, no significant difference was observed between unbiased and biased *d’* estimates when observers did not have a ‘neutral’ response.

Choice biases were estimated relative to surprise response rates, which generally had high hit rates and low erroneous response rates (see Supplemental Table 1 and 2). Although various choice biases were observed in both groups (see Figure 3), in the current project we chose to focus on those with a ‘neutral’ option because the inclusion of this response accounted for the differences between unbiased and biased *d’* estimates. Results (see Figure 3) demonstrate a significant bias for observers to use the ‘neutral’ response over ‘surprise’ when the target duration was between 5 and 40 ms. Conversely, with these target durations, the ‘surprise’ response was, excluding ‘happiness’, used more frequently than the remaining response options. With longer target durations, 80 to 500 ms, a choice bias for ‘neutral’ was no longer observed.

Neutral Response

In response to the observed choice bias, a 6 x 7 mixed-design ANOVA with ‘neutral’ response rates in the group with a neutral option was conducted, including target emotion and target duration as within subject variables. Results demonstrated significant main effects for target emotion, $F(3.11, 90.24) = 218.60$, $p < .001$, $\eta_G^2 = .26$, and target duration, $F(1.52, 44.16) = 357.68$, $p < .001$, $\eta_G^2 = .78$, in addition to a significant interaction between the two variables, $F(5.01, 145.23) = 35.34$, $p < .001$, $\eta_G^2 = .25$.

Figure 1

Mean Hit Rates for Each Expression (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Target Duration (5, 10, 20, 40, 80, 160, and 500 ms) with a 'Neutral' Option (white; dashed) and without a 'Neutral' Option (black; solid). Error Bars are Two Standard Error.

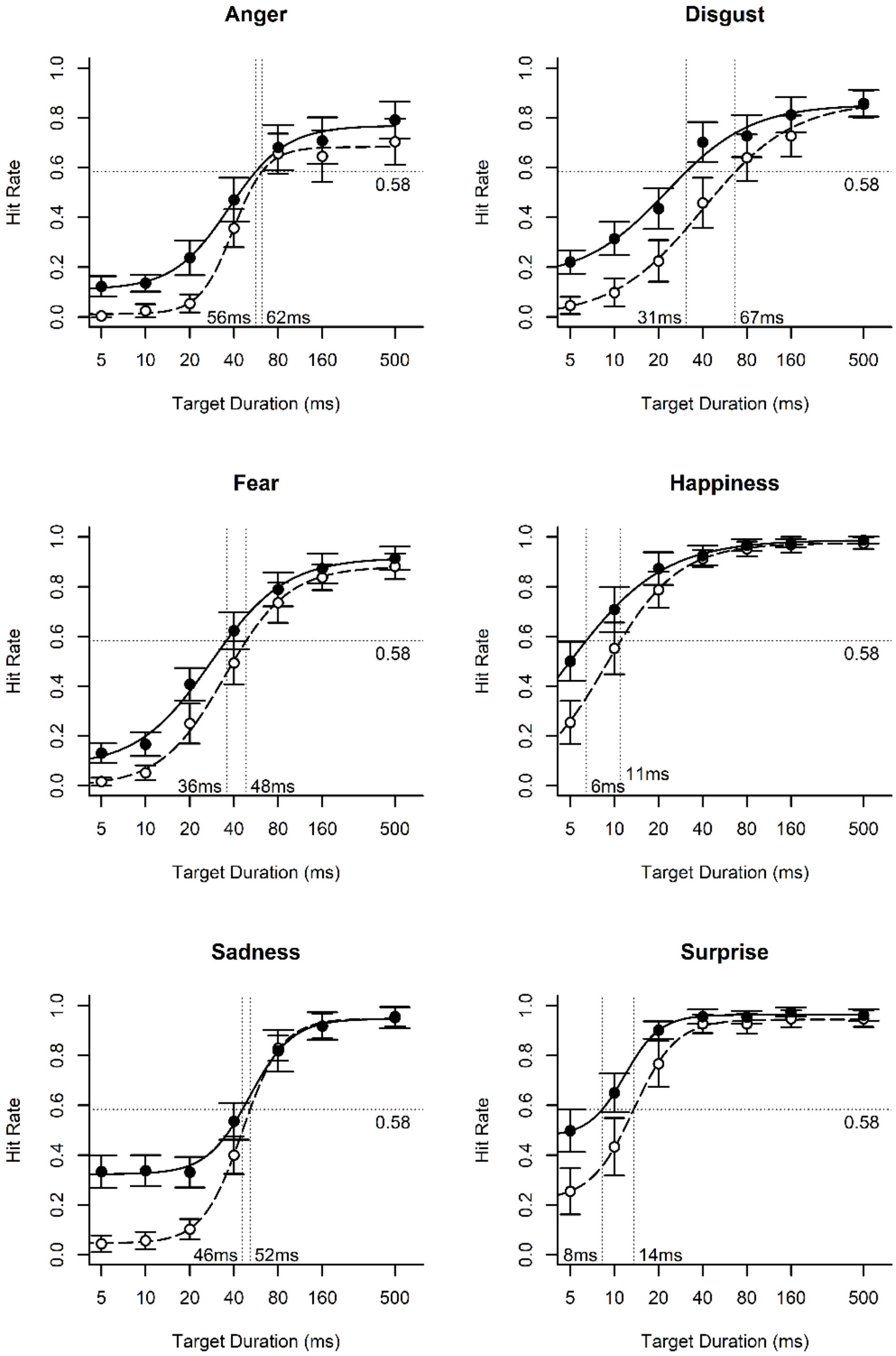
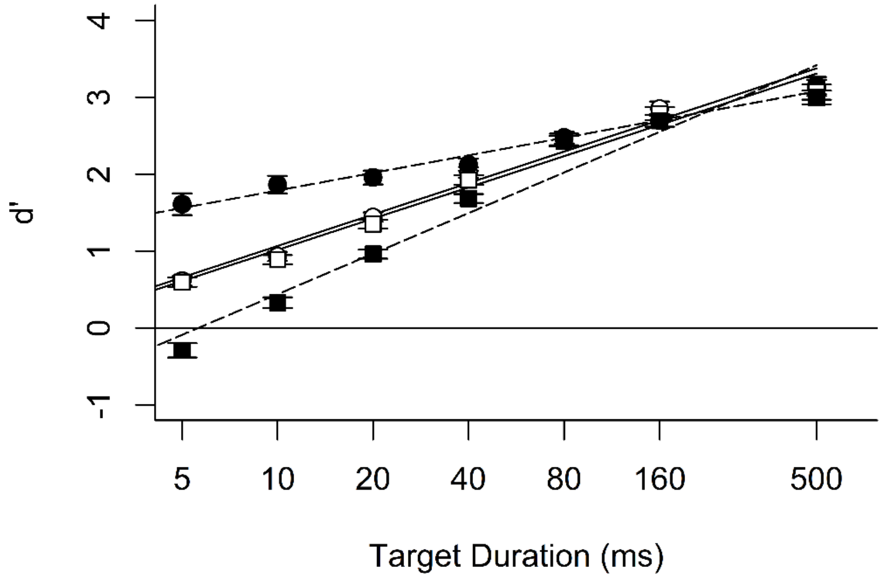


Figure 2

Unbiased (square) and Biased (circle) d' Estimates for Paradigms with 'Neutral' Option (black; dashed line) and without 'Neutral' Option (white; solid line).



Post hoc analyses explored the differences across target emotions at each target duration, which revealed that 'neutral' response rates only differed significantly with target durations of 40 ms and less. Results suggest the 'neutral' response was used more frequently for anger, disgust, fear, and sadness at 5 ms—as compared to happiness and surprise (all $p < .01$). The neutral response option was also used more frequently with anger than disgust at 5 ms durations ($p = .02$), but no other differences were observed across target emotions at this target duration (all $p > .05$).

From 10 to 40 ms, the 'neutral' response was used more frequently with anger and sadness than all other target emotions (all $p < .02$), with the exception of the comparison between disgust and sadness at 10 ms ($p = .06$). Conversely, this response was used less frequently from 10 to 40 ms with happiness and surprise than the remaining target emotions (all $p < .04$), with the exception of the comparison between happiness and disgust at 40 ms ($p = .07$). Finally, although no significant difference was observed between fear and disgust at 20 and 40 ms (both $p > .20$), the ‘neutral’ response was used more frequently with fear than disgust at 10 ms ($p = .04$).

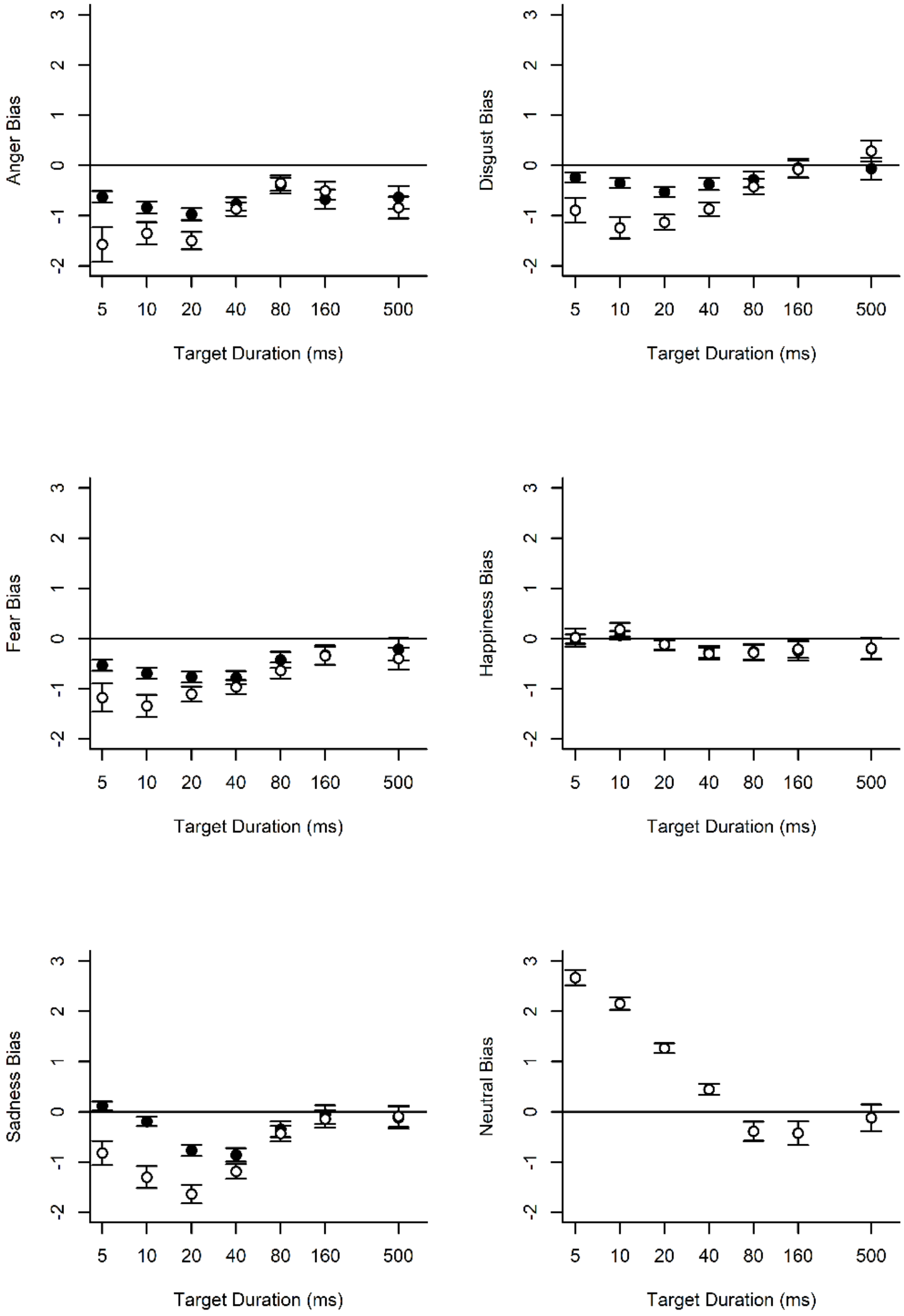
Discussion

The JACBART has been proposed as a standardized paradigm for measuring brief facial affect recognition (Matsumoto et al., 2000). Yet, little research has explored the factors that influence the paradigm (c.f. Chamberland & Collin, 2022; Matsumoto et al., 2000; Shen et al., 2012). For instance, the JACBART commonly offers a ‘none of the above’ and/or ‘neutral’ response option in addition to the emotional categories of the expressions presented in the study (e.g., Chamberland & Collin, 2022; Hurley, 2012; Hurley et al., 2014; Matsumoto & Hwang, 2011). Despite the benefit of reducing artifactual agreement (Frank & Stennett, 2001), the presentation of these additional response options is not typical in a psychophysical approach to explore recognition performance (e.g., Shen et al., 2012).

The current study explored how providing a ‘neutral’ option in a JACBART paradigm negatively impacts brief facial affect recognition performance. Specifically, it was hypothesized that the presence of this additional response option would make the paradigm a dual-task that first requires respondents to detect the presentation of an expression—by discriminating it from the neutral expression masks—then categorize said expression. Conversely, when the ‘neutral’ option was omitted from the paradigm, respondents would be forced to assume an expression was presented and categorize it regardless of their ability to detect said expression.

Figure 3

Response Bias Estimates with 'Neutral' Option (white) and without 'Neutral' Option (black) when compared to 'Surprise' Response Rates. Error Bars Represent 95% Confidence Intervals.



As demonstrated by DeCarlo (2012), biased *d*' estimates can be used to explore the influences of response biases on recognition performance when compared to unbiased *d*' estimates. As such, the differences observed between biased and unbiased *d*' estimates when a 'neutral' option is provided is of particular interest. Especially with no such differences observed when the 'neutral' option is not provided. With all other factors consistent across groups, this difference between the two groups suggests the 'neutral' option did indeed alter the brief affect recognition task. Specifically, we observed an effect that was specific to expressions presented for 40 ms and less, where respondents demonstrated a significant 'neutral' response bias. With that said, 'neutral' response rates were not consistent across expressions. At 5 ms, 'neutral' was more frequently used with expressions of anger, disgust, fear, and sadness compared to expressions of happiness and surprise. From 10 to 40 ms, although 'neutral' remained overall less common with expressions of happiness and surprise, the 'neutral' response was also less common with expressions of fear and disgust compared to expressions of anger and sadness.

The observed 'neutral' response biases are consistent with hit rate performances. Consistent with the findings of Shen et al. (2012), recognition performance with brief happiness and surprise expressions exceeded those of the remaining expressions—as demonstrated by their earlier psychometric thresholds. Both expressions exceeded the theoretical threshold for a 6AFC paradigm (i.e., ≈ 58%) at less than 20 ms regardless of the response options. Indeed, when no 'neutral' option was provided, recognition of expressions of happiness and surprise reached the threshold with as little as 6 and 8 ms displays. However, as evidenced by threshold locations and hit rate differences between groups, more time was needed when a 'neutral' option was provided. This suggests that, despite the high recognition performances, expressions of happiness and surprise did not remain unaffected by the presentation of a ‘neutral’ response at very brief target displays (i.e., 10 and 20 ms, respectively).

In contrast to the data with expressions of happiness and surprise, performance with brief anger and sadness expressions showed delayed psychometric thresholds compared to the remaining expressions and did not exceed the theoretical threshold before 40 ms regardless of the response options. Reduced recognition performance with expressions of anger and sadness relative to the remaining expressions is also consistent with the Shen et al. (2012). The presentation of a ‘neutral’ option also demonstrated little effect on the location of the theoretical threshold with these two expressions. However, as evidenced by hit rates, the ‘neutral’ option did affect sadness expression hit rates with durations of 40 ms and less. Expressions of anger conversely did not demonstrate a significant interaction between the presentation of a ‘neutral’ option and target duration.

With the observed ‘neutral’ option bias at durations of 40 ms and less, the poor recognition of anger regardless of the response option suggests respondents had increased difficulty guessing with expressions of anger. Indeed, an examination of the response matrix (see Supplemental Table 2) suggests the ‘sadness’ response was strategically used for expressions of anger at 10 ms and less. This confusion may be due to the facial actions shared between expressions of anger and sadness, including the brow lowerer and chin raiser (i.e., AUs 4 and 17) in the current study. Conversely, the commonly observed anger-disgust confusion (Gagnon et al., 2010; Gosselin et al., 1995; Jack et al., 2009) was for the most part only observed when individuals were presented with a ‘neutral’ option (see Supplemental Table 1).

Finally, with expressions of disgust and fear, theoretical threshold locations were below 40 ms when a ‘neutral’ option was not provided but above 40 ms when a ‘neutral’ option was provided. However, hit rate analyses suggest there was no significant difference between the two neutral response groups with expressions of fear. As such, the location of the theoretical threshold for expressions of fear can be assumed to be around 40 ms regardless of the 'neutral' option. Conversely, the 'neutral' option was observed to negatively affect hit rates with shorter durations of disgust expressions (i.e., 40 ms and less), and a longer target duration is needed to reach the theoretical threshold when the 'neutral' option is provided (i.e., 67 ms).

The observed benefit with brief expressions of happiness is not uncommon in emotion recognition tasks with facial expressions, and three accounts have been proposed to explain this advantage (see Nummenmaa & Calvo, 2015), termed 1) Frequency of occurrence, 2) Diagnostic Value, and 3) Affective Uniqueness. The first account, the *frequency of occurrence* hypothesis, posits that happy expressions commonly demonstrate a detection advantage because they are more frequently encountered in real-life social settings (Calvo et al., 2014). However, this hypothesis cannot fully account for the equal performance with expressions of surprise—as the observed frequency of these expressions did not differ from those of sadness or anger.

Instead, the current results appear to be largely accounted for by the *diagnostic value* hypothesis—as it posits that distinctive features (e.g., a big open smile) may facilitate featural recognition of the expression (Calvo & Nummenmaa, 2008). This would therefore suggest that, with the increased difficulty of the shorter durations, individuals may rely on bottom-up features that make it easier to discriminate between the expression and masks. Indeed, happy and surprise expressions would be expected to provide more visually salient information in the mouth region compared to the remaining expressions—as they include distinct higher intensity activations of the lip corner puller and jaw drop, respectively. Conversely, the distinctive features for anger (i.e., the lip tightener and lip pressor) may go more unnoticed because they do not present as large of a distinction from the neutral expressions.

Feature similarity cannot however account for the erroneous response biases observed with very brief durations (i.e., 20 ms and less; see Supplemental Table 1 and 2). More specifically, individuals demonstrated a general default to the ‘neutral’ option when it was provided but to ‘sadness’ when it was not. This pattern of erroneous responses in the face of uncertainty demonstrates strategic categorization (Russell, 1994) that appears to lend support for the *affective uniqueness* hypothesis. This account suggests that negative expressions (i.e., anger, fear, disgust, and sadness) are subject to affective interference because they share affective value (Mendolia, 2007). Conversely, happiness is the only positive expression and surprise is ambiguous. Increased difficulty with negative emotions in general—as compared to happiness and surprise—was demonstrated by increased ‘neutral’ response rates with durations of 5 to 40 ms. Conversely, when individuals did not have a ‘neutral’ option with these durations, the ’sadness’ response bias may be indicative that they were still capable of detecting the negative affective value of the expression. However, as disgust was the only negative expression that did not display this strategic categorization, the unique activation of the nose wrinkler in expressions of disgust may provide enough diagnostic value to distinguish it from the other negative emotions.

Limitations

Despite the fact respondents were specifically instructed to use the ‘neutral’ response option to indicate they were incapable of discriminating the target from the masks (i.e., they did not see an emotion), it is still probable that respondents may have chosen to use this response option as an “I don’t know” default when they were uncertain with the emotion categorization.

As such, increased ‘neutral’ response rates with shorter expression durations could also be related to lower emotion categorization confidence. Further studies will be needed to ensure the increased ‘neutral’ response rates are indicative of increased discrimination difficulty.

Although response biases throughout the emotion recognition task were measured through the sensitivity models, this measure was not able to assess how response biases differ across expressions of emotion. Due to the overwhelming number of conditions in the current study (i.e., 546 conditions), it was not possible to conduct a complete analysis of the response matrix without increasing the risk of type I errors. Erroneous responses across emotions were only assessed with the ‘neutral’ option. Nevertheless, though the findings should be considered with absolute caution, the complete response matrices are provided in Supplemental Table 1 and 2 with comparisons to chance (i.e., 1/6).

The current study was conducted with static images, which are fundamentally different from dynamic stimuli. Though dynamic stimuli would provide more ecological validity, they are also more complex (Matsumoto & Hwang, 2014). With limited empirical literature on the portrayal of micro-expressions (Porter & ten Brinke, 2008; Yan et al., 2013), too little is currently known about the temporal dynamics of the various micro-expression phases (i.e., onset, apex, and offset; e.g., Bugental, 1986; Cohn & Schmidt, 2004; Frank et al., 1993; Hess et al., 1989; Hess & Kleck, 1990; Horic-Asselin et al., 2020; Krumhuber & Kappas, 2005; Schmidt et al., 2001, 2006, 2009; Weiss et al., 1987). As evidenced by Kamachi and colleagues (2013), these dynamic factors have important implications in emotion recognition. As such, a better understanding of the temporal dynamics of micro-expressions portrayal is needed before accurate dynamic stimuli can be simulated.

Conclusion

The presentation of a ‘neutral’ option in the JACBART paradigm was observed to negatively impact recognition performances when facial expressions of emotion are presented for very short durations (i.e., 40 ms and less). However, the effects are not consistent across emotions. Although the use of a ‘neutral’ option has ecological validity and is proposed to reduce artifactual agreement (Frank & Stennett, 2001), the JACBART paradigm is evidently not a pure affect recognition task with shorter target durations. As such, future research will need to consider target durations when deciding whether to present a ‘neutral’ option in the JACBART paradigm. Failure to do so could result in the use of a dual-task consisting of expression detection and categorization.

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Supplemental Tables

Supplemental Table 1

Mean Response Rates (Standard Error) Compared to Chance for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Durations (5, 10, 20, 40, 80, 160, and 500 ms) Presented with a Neutral Option.

Response	5 ms	10 ms	20 ms	40 ms	80 ms	160 ms	500 ms
Expression of Anger							
Anger	0.00 (0.00)	0.03 (0.01)	0.05 (0.02)	0.36 (0.04) ***	0.66 (0.04) ***	0.65 (0.05) ***	0.70 (0.05) ***
Disgust	0.01 (0.00)	0.01 (0.01)	0.08 (0.02)	0.17 (0.03)	0.22 (0.03) †	0.26 (0.04) *	0.25 (0.04) *
Fear	0.01 (0.00)	0.01 (0.00)	0.02 (0.01)	0.03 (0.01)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)
Happiness	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.00 (0.00)	0.01 (0.01)	0.04 (0.01)	0.09 (0.02)	0.06 (0.02)	0.06 (0.01)	0.02 (0.01)
Surprise	0.00 (0.00)	0.01 (0.00)	0.04 (0.01)	0.02 (0.01)	0.01 (0.01)	---	0.00 (0.00)
Neutral	0.95 (0.01) ***	0.92 (0.02) ***	0.75 (0.05) ***	0.33 (0.04) ***	0.03 (0.01)	0.02 (0.02)	0.02 (0.02)
Expression of Disgust							
Anger	0.02 (0.01)	0.06 (0.02)	0.15 (0.03)	0.25 (0.04) *	0.25 (0.04) *	0.21 (0.03)	0.10 (0.02)
Disgust	0.05 (0.02)	0.10 (0.03)	0.23 (0.04) †	0.46 (0.05) ***	0.64 (0.05) ***	0.73 (0.04) ***	0.85 (0.03) ***
Fear	0.01 (0.01)	0.03 (0.01)	0.04 (0.01)	0.04 (0.01)	0.03 (0.01)	0.03 (0.01)	0.01 (0.01)
Happiness	0.04 (0.01)	0.11 (0.02)	0.15 (0.02)	0.09 (0.02)	0.02 (0.01)	0.00 (0.00)	---
Sadness	0.02 (0.01)	0.01 (0.01)	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)
Surprise	0.02 (0.01)	0.03 (0.01)	0.03 (0.01)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Neutral	0.84 (0.03) ***	0.67 (0.05) ***	0.39 (0.04) ***	0.12 (0.03)	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)
Expression of Fear							
Anger	---	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)	---
Disgust	0.02 (0.01)	0.01 (0.00)	0.03 (0.01)	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)
Fear	0.02 (0.01)	0.05 (0.02)	0.25 (0.04) *	0.49 (0.04) ***	0.74 (0.04) ***	0.84 (0.03) ***	0.88 (0.03) ***
Happiness	0.01 (0.01)	0.03 (0.01)	0.03 (0.01)	0.02 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.02 (0.01)	0.03 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
Surprise	0.02 (0.01)	0.08 (0.02)	0.20 (0.02) †	0.33 (0.03) ***	0.18 (0.03)	0.10 (0.02)	0.08 (0.02)
Neutral	0.91 (0.03) ***	0.78 (0.04) ***	0.45 (0.05) ***	0.12 (0.03)	0.04 (0.02)	0.02 (0.02)	0.02 (0.01)
Expression of Happiness							
Anger	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	---
Disgust	0.03 (0.01)	0.01 (0.00)	0.01 (0.00)	---	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Fear	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Happiness	0.25 (0.04) **	0.55 (0.05) ***	0.79 (0.04) ***	0.91 (0.02) ***	0.95 (0.01) ***	0.97 (0.02) ***	0.98 (0.01) ***
Sadness	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Surprise	0.01 (0.00)	0.04 (0.01)	0.04 (0.01)	0.01 (0.00)	0.01 (0.00)	0.01 (0.01)	0.00 (0.00)
Neutral	0.66 (0.05) ***	0.35 (0.05) ***	0.14 (0.03)	0.05 (0.02)	0.03 (0.01)	0.01 (0.01)	0.01 (0.01)
Expression of Sadness							
Anger	---	0.01 (0.00)	0.02 (0.01)	0.06 (0.01)	0.05 (0.01)	0.00 (0.00)	---
Disgust	0.01 (0.00)	0.01 (0.00)	0.04 (0.02)	0.05 (0.02)	0.04 (0.01)	0.02 (0.01)	0.01 (0.00)
Fear	0.01 (0.00)	0.01 (0.01)	0.03 (0.01)	0.04 (0.02)	0.02 (0.01)	0.02 (0.01)	0.00 (0.00)
Happiness	0.01 (0.00)	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Sadness	0.04 (0.02)	0.06 (0.02)	0.10 (0.02)	0.40 (0.04) ***	0.83 (0.03) ***	0.92 (0.03) ***	0.96 (0.02) ***
Surprise	0.01 (0.01)	0.01 (0.01)	0.04 (0.01)	0.04 (0.01)	0.01 (0.01)	0.01 (0.00)	0.00 (0.00)
Neutral	0.92 (0.02) ***	0.88 (0.03) ***	0.75 (0.04) ***	0.38 (0.05) ***	0.04 (0.01)	0.03 (0.02)	0.03 (0.02)
Expression of Surprise							
Anger	---	0.00 (0.00)	0.00 (0.00)	---	---	---	0.00 (0.00)
Disgust	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	---	0.01 (0.00)	---	---
Fear	0.03 (0.01)	0.03 (0.01)	0.04 (0.01)	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)
Happiness	0.01 (0.01)	0.01 (0.00)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)	---	0.00 (0.00)
Sadness	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)
Surprise	0.25 (0.05) *	0.43 (0.06) ***	0.77 (0.05) ***	0.93 (0.02) ***	0.93 (0.02) ***	0.95 (0.02) ***	0.95 (0.02) ***
Neutral	0.69 (0.05) ***	0.51 (0.06) ***	0.16 (0.04)	0.03 (0.01)	0.03 (0.02)	0.02 (0.01)	0.02 (0.01)

† *p* < .10, * *p* < .05, ** *p* < .01, *** *p* < .001

Supplemental Table 2

Mean Response Rates (Standard Error) Compared to Chance for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Durations (5, 10, 20, 40, 80, 160, and 500 ms) Presented without a Neutral Option.

Response	5 ms	10 ms	20 ms	40 ms	80 ms	160 ms	500 ms
Expression of Anger							
Anger	0.12 (0.02)	0.14 (0.02)	0.24 (0.03) *	0.47 (0.04) ***	0.68 (0.05) ***	0.71 (0.05) ***	0.79 (0.04) ***
Disgust	0.18 (0.02)	0.14 (0.02)	0.22 (0.02) *	0.19 (0.02)	0.17 (0.03)	0.18 (0.04)	0.14 (0.03)
Fear	0.12 (0.02)	0.10 (0.02)	0.08 (0.01)	0.05 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.00)
Happiness	0.14 (0.02)	0.17 (0.02)	0.13 (0.02)	0.05 (0.01)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Sadness	0.32 (0.03) ***	0.29 (0.03) ***	0.21 (0.02) †	0.17 (0.03)	0.11 (0.03)	0.09 (0.03)	0.05 (0.02)
Surprise	0.12 (0.02)	0.16 (0.02)	0.13 (0.02)	0.07 (0.02)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Expression of Disgust							
Anger	0.13 (0.02)	0.11 (0.02)	0.16 (0.03)	0.18 (0.04)	0.19 (0.03)	0.12 (0.03)	0.10 (0.02)
Disgust	0.22 (0.02) *	0.31 (0.03) ***	0.44 (0.04) ***	0.70 (0.04) ***	0.73 (0.04) ***	0.81 (0.04) ***	0.86 (0.03) ***
Fear	0.10 (0.02)	0.09 (0.01)	0.07 (0.02)	0.03 (0.01)	0.05 (0.02)	0.04 (0.01)	0.03 (0.01)
Happiness	0.20 (0.03)	0.23 (0.03) *	0.19 (0.03)	0.07 (0.02)	0.02 (0.01)	0.00 (0.00)	---
Sadness	0.21 (0.03) †	0.15 (0.02)	0.07 (0.01)	0.01 (0.00)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)
Surprise	0.15 (0.03)	0.10 (0.02)	0.08 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)
Expression of Fear							
Anger	0.09 (0.02)	0.08 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)	0.00 (0.00)
Disgust	0.19 (0.03)	0.16 (0.02)	0.09 (0.01)	0.03 (0.01)	0.03 (0.01)	0.01 (0.00)	0.01 (0.01)
Fear	0.13 (0.02)	0.17 (0.02)	0.41 (0.03) ***	0.62 (0.04) ***	0.79 (0.03) ***	0.87 (0.03) ***	0.91 (0.02) ***
Happiness	0.14 (0.02)	0.16 (0.02)	0.09 (0.01)	0.04 (0.01)	0.01 (0.00)	0.00 (0.00)	---
Sadness	0.26 (0.03) **	0.19 (0.02)	0.09 (0.02)	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	0.00 (0.00)
Surprise	0.19 (0.03)	0.25 (0.03) **	0.28 (0.02) ***	0.27 (0.03) ***	0.15 (0.03)	0.08 (0.02)	0.07 (0.02)
Expression of Happiness							
Anger	0.06 (0.01)	0.04 (0.01)	0.01 (0.00)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	---
Disgust	0.11 (0.02)	0.07 (0.02)	0.03 (0.02)	0.03 (0.01)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
Fear	0.06 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Happiness	0.50 (0.04) ***	0.71 (0.05) ***	0.87 (0.03) ***	0.93 (0.02) ***	0.97 (0.01) ***	0.98 (0.01) ***	0.99 (0.01) ***
Sadness	0.12 (0.02)	0.05 (0.02)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Surprise	0.15 (0.02)	0.09 (0.02)	0.04 (0.01)	0.02 (0.01)	0.00 (0.00)	---	---
Expression of Sadness							
Anger	0.11 (0.02)	0.11 (0.02)	0.13 (0.02)	0.13 (0.02)	0.05 (0.01)	0.01 (0.01)	0.00 (0.00)
Disgust	0.13 (0.03)	0.16 (0.02)	0.15 (0.02)	0.13 (0.02)	0.07 (0.02)	0.05 (0.02)	0.02 (0.01)
Fear	0.14 (0.02)	0.11 (0.01)	0.11 (0.01)	0.06 (0.01)	0.04 (0.01)	0.01 (0.01)	0.01 (0.01)
Happiness	0.16 (0.03)	0.15 (0.02)	0.11 (0.02)	0.06 (0.01)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.33 (0.03) ***	0.34 (0.03) ***	0.33 (0.03) ***	0.54 (0.04) ***	0.82 (0.04) ***	0.92 (0.03) ***	0.95 (0.02) ***
Surprise	0.13 (0.02)	0.14 (0.02)	0.16 (0.02)	0.08 (0.02)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)
Expression of Surprise							
Anger	0.06 (0.01)	0.04 (0.01)	0.01 (0.00)	0.00 (0.00)	---	---	---
Disgust	0.09 (0.02)	0.07 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	---	---
Fear	0.09 (0.01)	0.09 (0.02)	0.05 (0.01)	0.03 (0.01)	0.03 (0.01)	0.02 (0.01)	0.03 (0.01)
Happiness	0.08 (0.02)	0.07 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.18 (0.02)	0.09 (0.02)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
Surprise	0.50 (0.04) ***	0.65 (0.04) ***	0.90 (0.02) ***	0.96 (0.01) ***	0.95 (0.01) ***	0.98 (0.01) ***	0.96 (0.01) ***

† *p* < .10, * *p* < .05, ** *p* < .01, *** *p* < .001

Supplemental Table 3

Comparison of AIC Values of Various Probit, Logit, and Weibull Models with Fixed Asymptotes (λ = 0, γ = 0), A Varying Lambda (λ) Value (i.e., λ-Asymptote), or Varying Lambda (λ) and Gamma (γ) Values (i.e., 2-Asymptote).

				λ-Asymptote	2-Asymptote		
Emotion	Probit	Logit	Weibull	Probit	Probit	Logit	Weibull
With a Neutral Option							
Anger	541.72	570.57	653.68	293.24	53.65	52.00	1169.87
Disgust	186.64	198.18	279.99	124.30	52.35	51.63	66.59
Fear	325.31	324.00	482.27	190.97	47.49	48.94	156.47
Happiness	147.14	102.54	248.48	49.09	44.70	42.94	524.02
Sadness	298.46	260.67	524.63	147.41	47.50	45.06	51.96
Surprise	229.32	176.05	338.86	51.15	46.32	46.49	46.83
Without a Neutral Option							
Anger	173.77	182.89	247.53	67.76	54.62	53.45	67.52
Disgust	116.35	111.60	164.34	63.16	63.15	61.53	267.76
Fear	153.84	142.12	262.45	67.29	53.32	52.74	60.37
Happiness	73.40	54.91	109.83	45.52	44.45	42.55	319.57
Sadness	133.40	121.47	144.10	130.08	50.02	49.60	55.34
Surprise	159.78	123.76	212.54	56.58	44.94	44.55	45.17

Study 3

Subtle Micro-Expression Recognition: The Role of Expression Intensity in the Japanese and Caucasian Brief Affect Recognition Task

Abstract

Despite evidence that micro-expressions are typically low-intensity or partial facial expressions of emotion, prior research has only explored brief affect recognition performance with 100% intensity full-face expressions. The current study therefore sought to explore the temporal thresholds for the recognition of the six basic emotions using seven stimulus presentation durations (5, 10, 20, 40, 80, 160, and 500 ms), while manipulating the intensity of the target expression (50% vs. 100%). Results revealed a significant interaction between the category of expressed emotion, its display duration, and its display intensity. The intensity of the portrayed expression was observed to influence recognition performances at varying display durations for the different expressions of emotion. More specifically, the effect was observed with briefer durations for expressions of happiness and surprise than the remaining emotions. In addition, performances for happy and surprise expressions were observed to exceed chance thresholds with shorter display durations than the remaining emotions. Altogether, the current results demonstrate the varying temporal recognition characteristics of the six basic emotions according to display intensity.

Subtle Micro-Expression Recognition: The Role of Expression Intensity in the Japanese and Caucasian Brief Affect Recognition Task

Rooted in Darwin's (1872) inhibition hypothesis, the idea that facial muscles may involuntarily activate despite an individual's attempt to control their expressions of emotion has been proposed by several researchers (e.g., Ekman, 1985/2009; Ekman, 2003; Ekman & Rosenberg, 2005; Frank et al., 2009; Frank & Svetieva, 2015; Hurley, 2012; Hurley et al., 2014; Matsumoto & Hwang, 2011; Matsumoto et al., 2000; Porter and ten Brinke, 2008, or Yan et al., 2013). These brief moments of true expression are commonly referred to as micro-expressions and are suggested to occur for durations as short as 40 and 500 ms (Frank et al., 1993; Paul Ekman Group, n.d.; Matsumoto & Hwang, 2018; Yan et al., 2013). Additionally, while evaluating frame-by-frame muscle activations displayed by individuals attempting to conceal their expressions, micro-expressions were often observed to be partial (i.e., only in the upper or lower portion of the face) or lower intensity displays (Porter & ten Brinke, 2008; Yan et al., 2013). As such, some micro-expressions can be understood as brief full-face or subtle expressions—defined by Matsumoto and Hwang (2014) as full-face lower intensity configurations or partial configurations with specific action units.

As highlighted by Matsumoto and Hwang (2014), subtle expressions are less commonly explored in facial expression research. Work that has been done in this area shows that individuals can correctly categorize expressions at rates greater than chance with as little as 20% expression intensity, and that recognition capabilities improve monotonically with increased expression intensity (Calvo et al., 2016; Hess et al., 1997; Hoffmann et al., 2010; Matsumoto & Hwang, 2014; Palermo & Coltheart, 2004). However, with static expressions, a minimum intensity of 50% was required for all emotion recognition performances to exceed the psychometric chance threshold (Calvo et al., 2016).

The increased difficulty with lower intensity expressions may be problematic for people to be capable of recognizing micro-expressions—as no known research has explored recognition capabilities with brief displays of subtle expressions. Existing literature with full-face, full-intensity expressions has demonstrated that recognition grows increasingly difficult with shorter display durations (Calvo & Lundqvist, 2008; Chamberland & Collin, 2022a, 2022b; Esteves & Ohman, 1993; Kirouac & Doré, 1984; Matsumoto et al., 2000; Milders et al., 2008; Shen et al., 2012). Brief affect recognition is further increased in difficulty with a backward mask of at least 30 ms (Esteves & Ohman, 1993; Shen et al., 2012) and increased morphological similarity between the target and mask (Milders et al., 2008).

Matsumoto and colleagues (2000) proposed the Japanese and Caucasian Brief Affect Recognition Task (i.e., JACBART) as a standardized approach to measuring affect recognition performance. In this paradigm, a brief target expression of emotion is temporally displayed between two neutral expressions of the same individual. Despite the increased difficulty provided by the JACBART, individuals are still capable of categorizing emotions at rates greater than chance with very brief displays (i.e., 5 to 40 ms) though it differed across emotions (Chamberland & Collin, 2022b; Shen et al., 2012). Performances also reached the psychometric recognition threshold with briefer presentations of happiness and surprise (i.e., ≈ 5 to 10 ms), while longer presentations were required for anger and sadness (i.e., ≈ 40 to 50 ms; Chamberland & Collin, 2022b).

The current study sought to understand how micro-expression recognition performances are influenced by affect intensity. As such, full (100%) and subtle (50%) facial expressions of emotion are presented within a JACBART paradigm. Hit rates and sensitivity (*d*') were measured regarding the recognition of six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) and seven target durations (5, 10, 20, 40, 80, 160, and 500 ms). Psychometric functions are calculated for each emotion category and intensity (i.e., 12 conditions). We hypothesized that the lower intensity expressions would deliver less visual information about the emotion category to which they belong and would therefore require longer presentation durations in order to elicit threshold-level performance. Based on our past work, we also hypothesized that threshold duration would vary across emotion categories. Finally, we hypothesized that these two factors (emotion category and intensity) would interact in determining threshold presentation durations.

Methods

Participants

A total of 60 participants were recruited using the Integrated System of Participation in Research (ISPR) student pool at the University of Ottawa. These individuals were pseudo-randomly assigned to view target expressions at either 100% intensity (6 males and 24 females; M_{Age} = 19.30, *SD* = 2.09)[2] or 50% intensity (7 males and 23 females; M_{Age} = 19.50, *SD* = 5.94).

Materials

The images of facial expressions were adapted from Chamberland and Collin (2022a, 2022b), which originated from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE), Standard Version (Matsumoto, & Ekman 1988). These 28 expressions included two male (JC and SW1) and two female (MM and NH1) actors each portraying six FACS-coded expressions of emotion (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and one neutral

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[2] Data for the 100% intensity sample was taken directly from Chamberland and Collin (2022b) for comparison to the new sample with 50% intensity expressions.

expression. In Adobe Photoshop, the expressions of emotion were centered to their neutral expression counterparts—using the nasion in the face images—and cropped to have a pixel dimension of 600 by 625 (72 dpi). Finally, the resulting grey-scaled images were luminance corrected in MATLAB by ensuring that the mean and RMS of pixel values in each image were the same as the overall mean and RMS for all images in our stimulus set.

Expression intensity was manipulated through the image editing software called Morpheus Photo Morpher (Morpheus Development, Howell, MI). For each actor and expression, the neutral (0% emotion) and target expression of emotion (100% emotion) obtained from the JACFEE database were used as start and end points for an expression. The software then generated a series of intermediary images that were morphed to different degrees between the neutral and fully expressive face. From these, the mid-point image was taken to represent a 50% intensity expression. All images were presented on a 24.5” ASUS ROG Swift PG258Q monitor operating at a 200 Hz frame rate and 1920 by 1080 resolution[3].

Procedure

The JACBART paradigm (Matsumoto et al., 2000) was presented using the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997; Kleiner, Brainard, & Pelli, 2007) on MATLAB R2019a (The Math Works, Inc., 2019), with a Linux operating system. In the current study, participants were instructed that three images would be presented on each trial: First a neutral expression, then an expressive one, then a neutral one. They were also told that their task was to categorize the expression on the image presented between two neutral expression images (i.e., the expression of the target image). This target expression was presented with either 100%

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[3] Despite existing evidence that the ASUS ROG Swift PG258Q accurately presents frame changes at up to 240 Hz (Shi, 2017), a Sony DSC-RX10IV Cyber-Shot camera was used to capture images of our stimuli on the computer screen at 1000 fps. Results confirmed that targets presented for 1 frame, at 200 Hz, were indeed presented for 5 ms.

or 50% intensity, as per group assignment, and a display time of 5, 10, 20, 40, 80, 160, or 500 ms (i.e., 1, 2, 4, 8, 16, 32, or 100 frames at 200 Hz). Meanwhile, the presentation of the preceding neutral expression forward mask randomly varied between 750 and 1250 ms, with 5 ms intervals, and the succeeding neutral expression backward mask was fixed at 1000 ms. Each series of images only included expressions portrayed by a single actor throughout the trial and was followed by the question "Which emotion was expressed?" with six response options ('anger', 'disgust', 'fear', 'happiness', 'sadness', and 'surprise'). Following a participant response, a 500 ms inter-trial blank screen was presented.

To familiarize participants with this task, a brief practice block was provided to demonstrate each of the target expression display times at least once, with the target expression selected at random. After a brief break to allow for questions, a set of 672 experimental trials were presented in random order[4]. These break down as follows: 6 target expressions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) × 7 target durations (5, 10, 20, 40, 80, 160, and 500 ms) × 4 face identities per expression × 4 repetitions per image. Participants were offered the opportunity to rest after every 100 trials to reduce fatigue.

Results

Data were processed and analyzed in R version 3.6.1 (R Core Team, 2019). Trial response data were converted to binary indicators for each categorical response option ('anger', 'disgust', 'fear', 'happiness', 'sadness', or 'surprise'), with values of '1' and '0' respectively indicating whether the response option was or was not used for the trial (see Supplemental Table 1 and 2). Hit rates were subsequently calculated using these response indicators by assigning a

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[4] The experimental task was programmed to ensure that the display time of the target expression was accurately presented for the desired durations. The trial would be flagged if an inaccuracy was detected, and its image would be re-added at the end of the trial list for the target display time. However, a review of the data indicates no inaccuracies were flagged throughout the study.

‘1’ value when the response corresponded with the intended alternative (e.g., an ‘anger’ response for an angry expression; i.e., a hit) and a ‘0’ value when the response did not correspond with the intended alternative (e.g., a ‘disgust’ response for an angry expression; i.e., a miss). Hit rates were then analysed via ANOVAs, with Greenhouse-Geisser corrections applied wherever the sphericity assumption was violated. Post-hoc analyses consisted of Bonferroni-corrected t-tests.

Response indicators were also used to calculate so-called biased d’ estimates, where a respondent is assumed to display potential bias toward one or more response categories during an m-alternative forced-choice task (mAFC; DeCarlo, 2012; Hautus et al., 2021). Logit models were calculated using the ‘gmnl’ function in R (Sarrias & Daziano, 2017) but corrected, to account for the increased scaling relative to probit models, by dividing the logit estimate by 1.28 (i.e., $\sqrt{\pi^2/6}$; Train, 2003/2009/2014).

Hit Rates

Hit rates for all conditions are shown in Figure 1. A 2 (Expression Intensity: 50% or 100%) x 6 (Target Emotion: Anger, Disgust, Fear, Happiness, Sadness, and Surprise) x 7 (Target Duration: 5, 10, 20, 40, 80, 160, and 500 ms) mixed-design ANOVA was applied to the hit rate data, with target emotion and target duration as within-subjects variables and expression intensity as a between-subjects variable. Results demonstrate significant main effects for expression intensity, target emotion, and target duration (see Table 1). Additionally, all variable pairings demonstrated significant interactions, including the higher-order interaction between all three variables.

A series of 2 x 7 mixed-design ANOVAs, one for each target emotion, was subsequently run with expression intensity and target duration as between-subject and within-subject variables, respectively. However, for the sake of brevity, only post-hoc analyses are reported here, with a focus on the interactions. Significant main effects are reported when an interaction was not significant. That being said, disgust was the only expression that did not demonstrate a significant interaction between expression intensity and target duration. A main effect for target duration was instead observed, with significant benefits observed for each increase in display time (all $p \leq .013$). For the remaining target emotions, interaction patterns varied.

Table 1

Mixed-Design ANOVAs with Expression Intensity (100% vs. 50%), Target Emotion (Anger, Disgust, Fear, Happiness, Sadness, and Surprise), and Target Duration (5, 10, 20, 40, 80, 160, and 500 ms) for Hit Rates.

	df	*F*	η_G^2
Expression Intensity	1, 58	22.47 ***	.06
Target Emotion	3.96, 229.48	142.73 ***	.43
Target Duration	3.24, 187.85	1098.87 ***	.63
Expression Intensity × Target Emotion	3.96, 229.48	2.43 *	.01
Expression Intensity × Target Duration	3.24, 187.85	5.05 **	.01
Target Emotion × Target Duration	11.37, 659.63	24.12 ***	.15
Expression Intensity × Target Emotion × Target Duration	11.37, 659.63	5.92 ***	.04

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

For happiness and surprise, individuals with the 100% intensity expressions performed better than those with the 50% intensity expressions only with the shorter display times (i.e., 5, 10, and 20 ms; all $p \leq .01$), except with happy expressions at 5 ms ($p = .06$). Conversely, significant differences were more prominent in the longer display times with the remaining expressions. For instance, expression intensity significantly benefitted hit rates for expressions of fear with display times from 20 to 500 ms (all $p \leq .03$). A similar benefit was observed with sad expressions displayed for 40 to 160 ms (all $p \leq .02$) and angry expressions displayed for 80 ms ($p = .03$).

Psychometric Functions

The ‘psyfun.2asym’ function (Knoblauch, 2014) was used to fit logit models to the hit rate data. The fitted functions were not constrained to fit theoretical performance minima and maxima. That is, the curve fitting algorithm did not attempt to fit a function ranging from a theoretical maximum hit proportion of 1 and a theoretical minimum of 16.67% (i.e., chance-level performance with 6 options); Instead, the ceiling and floor of the function were allowed to be free parameters along with the intercept and slope. This therefore provided estimates for the intercept (β_0), slope (β_1), and the upper (1- λ) and lower (γ) asymptotes. These values can then be used to calculate the observed threshold, its location, and the function's scale (see Table 2; Knoblauch & Maloney, 2012). Psychometric functions can be viewed in Figure 1 with the theoretical threshold for a 6AFC task (≈ .58) based on the above-mentioned constraints.

Table 2

Psychometric Function Parameters for the Logit Models, Including the Observed Performance Threshold, Location of the Threshold (ms), Scale of the Linear Continuum, Intercept (β_0), Slope (β_1), Lambda (λ, where 1- λ is the fitted upper bound), and Gamma (γ, the fitted lower bound).

Target Emotion	Threshold	Location	Scale	β_0	β_1	λ	γ
100% Intensity Expressions							
Anger	0.44	37.06	0.64	-4.55	1.57	0.23	0.11
Disgust	0.50	22.82	0.94	-2.32	1.06	0.15	0.16
Fear	0.50	27.89	0.84	-2.96	1.19	0.08	0.08
Happiness	0.49	4.90	1.07	0.03	0.94	0.01	0.00
Sadness	0.64	50.98	0.48	-6.92	2.06	0.05	0.32
Surprise	0.72	11.73	0.40	-3.06	2.49	0.04	0.48
50% Intensity Expressions							
Anger	0.39	41.41	0.86	-3.56	1.17	0.33	0.11
Disgust	0.48	26.39	1.40	-1.72	0.71	0.11	0.08
Fear	0.47	66.81	0.92	-4.05	1.08	0.14	0.08
Happiness	0.66	16.59	0.60	-2.88	1.67	0.03	0.34
Sadness	0.60	91.90	0.39	-10.71	2.55	0.09	0.29
Surprise	0.63	14.44	0.41	-3.77	2.47	0.07	0.33

Comparisons of Hit Rates to Chance-Level Performance

Single-sample t-tests were used to compare hit rates to the 6AFC chance value of 0.17 (i.e., 1/6). For each expression intensity and target emotion, this analysis was performed starting with the shortest target duration (i.e., 5ms) and proceeded with larger target durations until the hit rate exceeded chance (see Supplemental Table 1 and 2). This was effective in reducing the number of tests required, as most recognition rates exceeded chance with the shorter display times. For instance, individuals recognized expressions of happiness, sadness, and surprise at rates greater than chance with as little as 5 ms regardless of the expression intensity (all $p <$ .001). Conversely, more time was generally needed with the remaining expressions. Individuals were capable of recognizing 5 ms displays of a disgust expression with a 100% intensity ($p =$ .02) though 10 ms was needed to recognize the 50% intensity expressions ($p < .001$). However, it should be noted that the 5 ms displays of disgust with a 50% intensity were nearly above chance ($p = .07$). Finally, similar patterns were observed with expressions of anger and fear. Those showed that 100% intensity expressions of these two emotions were capable of eliciting hit rates greater than chance with the 20 ms display time (both $p \leq .03$) but not with the shorter durations (i.e., 5 and 10 ms; both $p \geq .50$). Conversely, 40 ms was needed for recognition with the 50% intensity versions of these expressions (both $p < .001$)—as hit rates did not exceed chance with the shorter display times (i.e., 5, 10, and 20; all $p \geq .36$). However, the hit rate for a 20 ms display of the 50% anger expression was nearly above chance ($p = .06$).

Sensitivity

Multinomial logit models were run using the ‘gmnl’ function in R (Sarrias & Daziano, 2017) to estimate sensitivity (*d*’) and response biases (see DeCarlo, 2012). Results indicate that individuals viewing the 100% intensity expressions performed better with the recognition task than those with the 50% intensity expressions for all target durations. In addition, response bias estimates, for the most part, demonstrated a consistent bias away from the ‘anger’ response despite all target expressions having equal display frequencies throughout the experiment (see Figure 2).

Figure 1

Mean Hit Rates for Each Expression (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Target Duration (5, 10, 20, 40, 80, 160, and 500 ms) with 100% (black; solid) and 50% (white; dashed) Intensity Expressions. Error Bars are Two Standard Error.

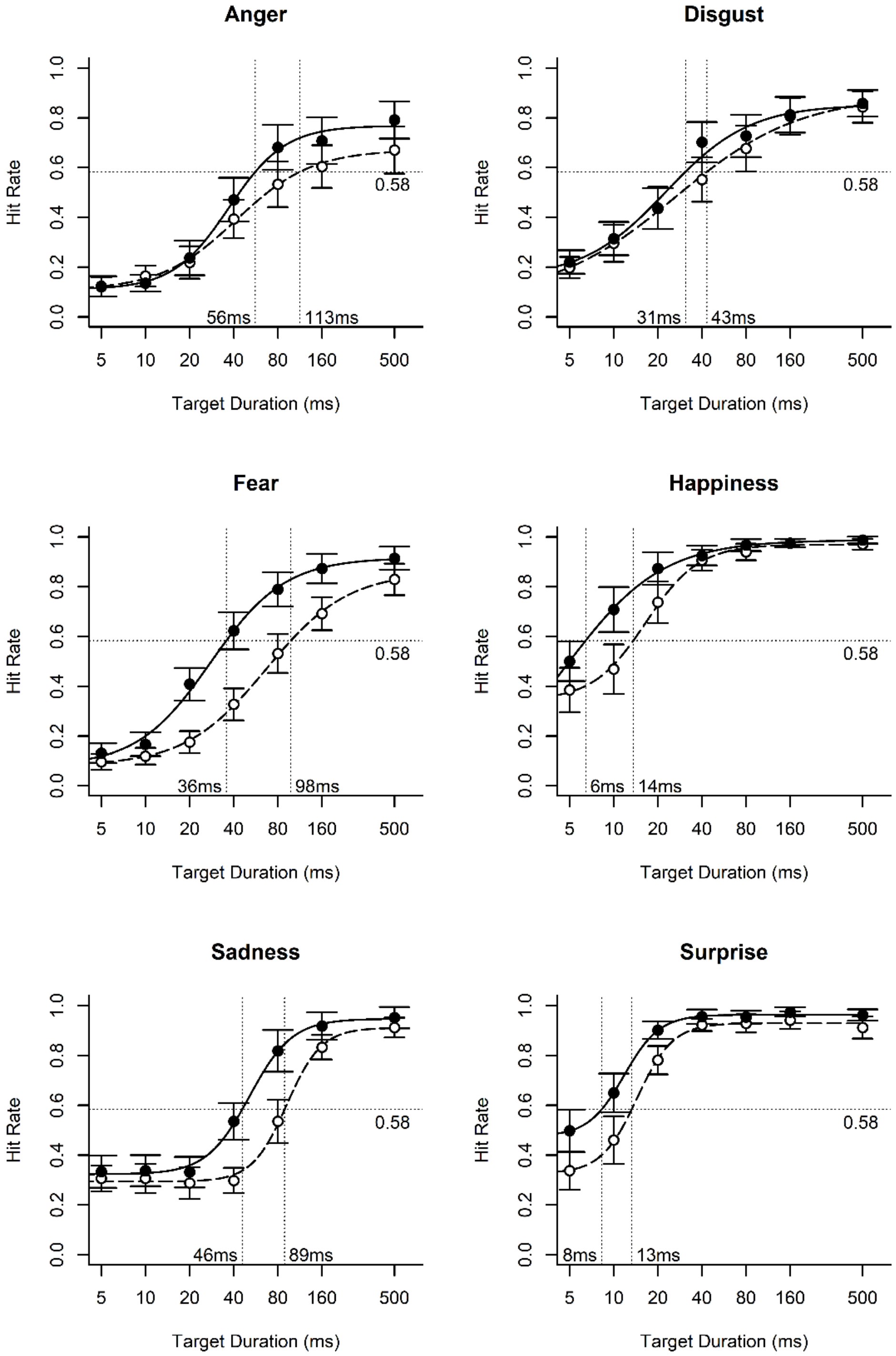
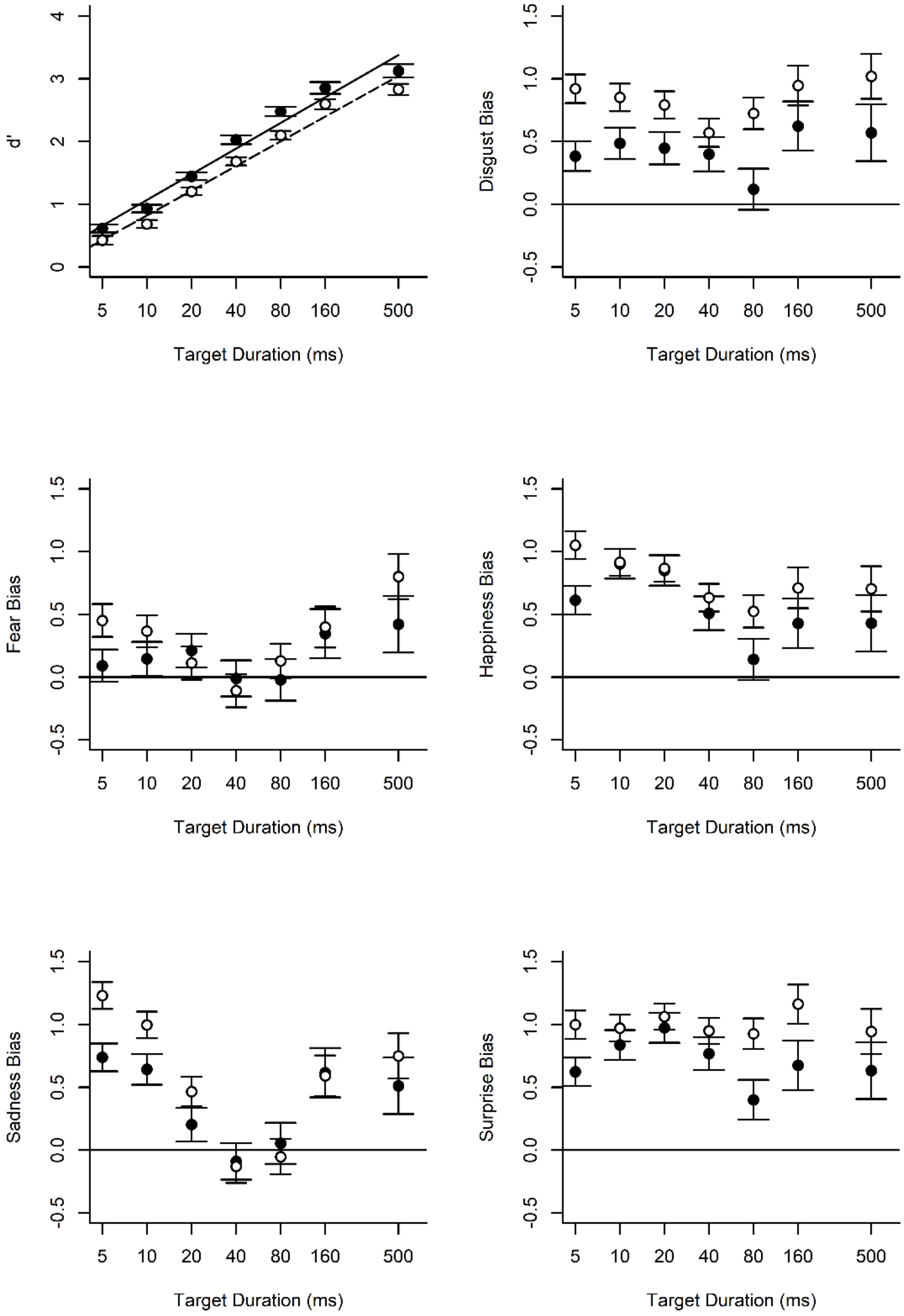


Figure 2

Biased d' Estimates and Response Bias Estimates, compared to 'Anger' Response Rates, with 100% (black) and 50% (white) Intensity Expressions. Error Bars Represent 95% Confidence Intervals.



Discussion

Empirical evidence of micro-expressions (Porter & ten Brinke, 2008; Yan et al., 2013) suggest that these brief displays of true emotions can be portrayed as full-face or subtle expressions—defined by Matsumoto and Hwang (2014) as full-face lower intensity configurations or partial configurations with specific action units. Despite this, no known research has explored recognition of brief subtle expressions. There is however evidence that a minimum intensity of 20% is required for emotion categorization to exceed chance (Calvo et al., 2016; Hess et al., 1997; Hoffmann et al., 2010; Matsumoto & Hwang, 2014; Palermo & Coltheart, 2004), and a minimum intensity of 50% is required to exceed the psychometric chance threshold (Calvo et al., 2016). With this research in mind, the current study explored micro-expression recognition performances with full (100% intensity) and subtle (50% intensity) facial expressions of emotion presented within a JACBART paradigm.

Existing literature with full facial expressions has demonstrated that increased display durations contribute to improved recognition performances in an affect recognition task (Calvo & Lundqvist, 2008; Chamberland & Collin, 2022a, 2022b; Esteves & Ohman, 1993; Kirouac & Doré, 1984; Matsumoto et al., 2000; Milders et al., 2008; Shen et al., 2012). Recent evidence has also demonstrated that individuals exceeded chance-level emotion categorization performance with very brief expression durations (i.e., 40 ms or less), though differences are observed across emotions (Chamberland & Collin, 2022b; Shen et al., 2012). Indeed, the current data suggests subtle expression recognition exceeds chance-level performance with less than 10 ms when presented 50% intensity expressions of disgust, happiness, sadness, and surprise. Conversely, approximately 40 ms was needed to recognize 50% intensity expressions of anger, fear, and sadness at rates above chance.

Similarly, although Chamberland and Collin (2022b) demonstrated that the presentation of a 'neutral' option had a negative impact on performance, shorter durations were generally required for performances to reach the theoretical psychometric threshold (≈ 58%) with expressions of happiness and surprise (i.e., 6 and 8 ms). Conversely, longer durations were required to reach this threshold with expressions of anger and sadness (i.e., 56 and 46 ms)[5]. This trend was mirrored with subtle expressions, but expression intensity was observed to negatively affect performances with all emotions except disgust. More specifically, although it took approximately 43 ms for 50% disgust expressions to reach the theoretical threshold—a 12 ms increase compared to its 100% intensity counterpart—hit rate comparisons suggest the difference in performance between the two intensities was not significant.

With happiness and surprise, subtle 50% expressions reached the theoretical threshold relatively quickly compared to the remaining subtle expressions (i.e., 14 and 13 ms)—as is commonly observed with the 100% expressions (Chamberland & Collin, 2022b; Shen et al., 2012). However, in spite of this only being a respective 8 and 5 ms increase relative to their 100% happiness and surprise expression counterparts, hit rate comparisons with these two expressions demonstrated a significant difference between the two intensities at durations of 20 ms and less. These findings suggest that intensity negatively affected recognition performances with happiness and surprise expressions at the very brief target durations.

These findings appear to contrast with those with expressions of anger, fear, and sadness. Relative to the other emotions, longer durations were needed for recognition performances to reach the theoretical threshold with 50% expressions of anger, fear, and sadness (i.e., 113, 98, and 89 ms, respectively). This represents a minimum increase of 43 ms compared to their 100%

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[5] This data is presented as the full facial expression data in the current study.

counterparts. Hit rate comparisons suggest these threshold differences are significant with expressions of fear and sadness, with 100% expressions having larger hit rates than 50% expressions when the duration was 40 ms or greater. Conversely, given that a significant difference was only observed between intensities when an expression of anger was presented for 80 ms, expression intensity appears to only affect anger recognition performances around this duration.

Limitations

The current study chose to only present expressions with durations up to 500 ms—as it represents the upper limit for the duration of micro-expressions (Frank et al., 1993; Paul Ekman Group, n.d.; Matsumoto & Hwang, 2018; Yan et al., 2013). However, current data demonstrated significant differences between the 100% and 50% intensities with expressions of fear and sadness at 500 ms. As such, differences between the two intensities may also be present with longer expressions of these emotions (i.e., greater than 500 ms). If this is the case, although the psychometric functions present good fit with the current data, changes to the upper bound limit (i.e., the maxima) could influence the observed threshold estimates. However, the current study specifically chose to focus on the theoretical threshold (i.e., 58%), as it would remain unchanged across emotions. The locations of the theoretical threshold across emotion should also remain largely unchanged by alterations to the upper bound limit. Nonetheless, this must be a consideration when interpreting the current data.

Conclusion

The current study adds to our understanding of micro-expression recognition performances with subtle expressions. The intensity of a facial expression of emotion was observed to significantly affect recognition performance with all emotions except disgust.

However, the effect of intensity differed across emotions. Although performances with subtle (i.e., 50% intensity) expressions of happiness and surprise reached the theoretical threshold at approximately 14 ms, hit rates were still significantly lower than their 100% intensity counterparts with durations of 20 ms and less. Conversely, differences between intensities were predominantly in the longer durations with expressions of anger, fear, and sadness. More specifically, intensity was observed to significantly affect performance with durations of 20 ms and more with expressions of fear, 40 ms and more with expressions of sadness, and a duration of 80 ms with expressions of anger.

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Supplemental Tables

Supplemental Table 1

Mean Response Rates (Standard Error) Compared to Chance for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Durations (5, 10, 20, 40, 80, 160, and 500 ms) Presented at 100% Intensity.

Response	5 ms	10 ms	20 ms	40 ms	80 ms	160 ms	500 ms
Expression of Anger							
Anger	0.12 (0.02)	0.14 (0.02)	0.24 (0.03) *	0.47 (0.04) ***	0.68 (0.05) ***	0.71 (0.05) ***	0.79 (0.04) ***
Disgust	0.18 (0.02)	0.14 (0.02)	0.22 (0.02) *	0.19 (0.02)	0.17 (0.03)	0.18 (0.04)	0.14 (0.03)
Fear	0.12 (0.02)	0.10 (0.02)	0.08 (0.01)	0.05 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.00)
Happiness	0.14 (0.02)	0.17 (0.02)	0.13 (0.02)	0.05 (0.01)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Sadness	0.32 (0.03) ***	0.29 (0.03) ***	0.21 (0.02) †	0.17 (0.03)	0.11 (0.03)	0.09 (0.03)	0.05 (0.02)
Surprise	0.12 (0.02)	0.16 (0.02)	0.13 (0.02)	0.07 (0.02)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Expression of Disgust							
Anger	0.13 (0.02)	0.11 (0.02)	0.16 (0.03)	0.18 (0.04)	0.19 (0.03)	0.12 (0.03)	0.10 (0.02)
Disgust	0.22 (0.02) *	0.31 (0.03) ***	0.44 (0.04) ***	0.70 (0.04) ***	0.73 (0.04) ***	0.81 (0.04) ***	0.86 (0.03) ***
Fear	0.10 (0.02)	0.09 (0.01)	0.07 (0.02)	0.03 (0.01)	0.05 (0.02)	0.04 (0.01)	0.03 (0.01)
Happiness	0.20 (0.03)	0.23 (0.03) *	0.19 (0.03)	0.07 (0.02)	0.02 (0.01)	0.00 (0.00)	---
Sadness	0.21 (0.03) †	0.15 (0.02)	0.07 (0.01)	0.01 (0.00)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)
Surprise	0.15 (0.03)	0.10 (0.02)	0.08 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)
Expression of Fear							
Anger	0.09 (0.02)	0.08 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)	0.00 (0.00)
Disgust	0.19 (0.03)	0.16 (0.02)	0.09 (0.01)	0.03 (0.01)	0.03 (0.01)	0.01 (0.00)	0.01 (0.01)
Fear	0.13 (0.02)	0.17 (0.02)	0.41 (0.03) ***	0.62 (0.04) ***	0.79 (0.03) ***	0.87 (0.03) ***	0.91 (0.02) ***
Happiness	0.14 (0.02)	0.16 (0.02)	0.09 (0.01)	0.04 (0.01)	0.01 (0.00)	0.00 (0.00)	---
Sadness	0.26 (0.03) **	0.19 (0.02)	0.09 (0.02)	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	0.00 (0.00)
Surprise	0.19 (0.03)	0.25 (0.03) **	0.28 (0.02) ***	0.27 (0.03) ***	0.15 (0.03)	0.08 (0.02)	0.07 (0.02)
Expression of Happiness							
Anger	0.06 (0.01)	0.04 (0.01)	0.01 (0.00)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	---
Disgust	0.11 (0.02)	0.07 (0.02)	0.03 (0.02)	0.03 (0.01)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
Fear	0.06 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Happiness	0.50 (0.04) ***	0.71 (0.05) ***	0.87 (0.03) ***	0.93 (0.02) ***	0.97 (0.01) ***	0.98 (0.01) ***	0.99 (0.01) ***
Sadness	0.12 (0.02)	0.05 (0.02)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Surprise	0.15 (0.02)	0.09 (0.02)	0.04 (0.01)	0.02 (0.01)	0.00 (0.00)	---	---
Expression of Sadness							
Anger	0.11 (0.02)	0.11 (0.02)	0.13 (0.02)	0.13 (0.02)	0.05 (0.01)	0.01 (0.01)	0.00 (0.00)
Disgust	0.13 (0.03)	0.16 (0.02)	0.15 (0.02)	0.13 (0.02)	0.07 (0.02)	0.05 (0.02)	0.02 (0.01)
Fear	0.14 (0.02)	0.11 (0.01)	0.11 (0.01)	0.06 (0.01)	0.04 (0.01)	0.01 (0.01)	0.01 (0.01)
Happiness	0.16 (0.03)	0.15 (0.02)	0.11 (0.02)	0.06 (0.01)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.33 (0.03) ***	0.34 (0.03) ***	0.33 (0.03) ***	0.54 (0.04) ***	0.82 (0.04) ***	0.92 (0.03) ***	0.95 (0.02) ***
Surprise	0.13 (0.02)	0.14 (0.02)	0.16 (0.02)	0.08 (0.02)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)
Expression of Surprise							
Anger	0.06 (0.01)	0.04 (0.01)	0.01 (0.00)	0.00 (0.00)	---	---	---
Disgust	0.09 (0.02)	0.07 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	---	---
Fear	0.09 (0.01)	0.09 (0.02)	0.05 (0.01)	0.03 (0.01)	0.03 (0.01)	0.02 (0.01)	0.03 (0.01)
Happiness	0.08 (0.02)	0.07 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.18 (0.02)	0.09 (0.02)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
Surprise	0.50 (0.04) ***	0.65 (0.04) ***	0.90 (0.02) ***	0.96 (0.01) ***	0.95 (0.01) ***	0.98 (0.01) ***	0.96 (0.01) ***

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Supplemental Table 2

Mean Response Rates (Standard Error) Compared to Chance for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Durations (5, 10, 20, 40, 80, 160, and 500 ms) Presented at 50% Intensity.

Response	5 ms	10 ms	20 ms	40 ms	80 ms	160 ms	500 ms
Expression of Anger							
Anger	0.12 (0.02)	0.16 (0.02)	0.22 (0.03) †	0.39 (0.04) ***	0.53 (0.05) ***	0.60 (0.04) ***	0.67 (0.05) ***
Disgust	0.20 (0.02) †	0.18 (0.02)	0.27 (0.03) **	0.27 (0.03) **	0.30 (0.04) ***	0.25 (0.03) **	0.22 (0.04) †
Fear	0.07 (0.01)	0.10 (0.02)	0.08 (0.02)	0.06 (0.01)	0.04 (0.01)	0.03 (0.01)	0.04 (0.02)
Happiness	0.17 (0.03)	0.14 (0.02)	0.13 (0.02)	0.05 (0.01)	0.01 (0.01)	0.01 (0.00)	0.00 (0.00)
Sadness	0.31 (0.03) ***	0.28 (0.03) ***	0.18 (0.03)	0.16 (0.02)	0.09 (0.02)	0.10 (0.02)	0.06 (0.02)
Surprise	0.13 (0.03)	0.13 (0.03)	0.12 (0.03)	0.06 (0.03)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)
Expression of Disgust							
Anger	0.14 (0.02)	0.15 (0.02)	0.22 (0.03) *	0.27 (0.04) **	0.21 (0.04)	0.15 (0.03)	0.11 (0.03)
Disgust	0.20 (0.02) †	0.30 (0.04) ***	0.44 (0.04) ***	0.55 (0.04) ***	0.68 (0.05) ***	0.81 (0.04) ***	0.84 (0.03) ***
Fear	0.09 (0.01)	0.08 (0.01)	0.05 (0.01)	0.03 (0.01)	0.04 (0.01)	0.03 (0.01)	0.03 (0.01)
Happiness	0.18 (0.02)	0.17 (0.03)	0.09 (0.02)	0.08 (0.02)	0.05 (0.01)	0.00 (0.00)	0.00 (0.00)
Sadness	0.27 (0.03) **	0.20 (0.03)	0.10 (0.02)	0.03 (0.01)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)
Surprise	0.13 (0.03)	0.11 (0.03)	0.09 (0.03)	0.04 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Expression of Fear							
Anger	0.10 (0.01)	0.11 (0.02)	0.10 (0.02)	0.04 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Disgust	0.18 (0.02)	0.14 (0.02)	0.14 (0.02)	0.08 (0.01)	0.04 (0.01)	0.01 (0.01)	0.01 (0.01)
Fear	0.10 (0.02)	0.12 (0.02)	0.18 (0.02)	0.33 (0.03) ***	0.53 (0.04) ***	0.69 (0.03) ***	0.83 (0.03) ***
Happiness	0.14 (0.02)	0.15 (0.02)	0.13 (0.02)	0.08 (0.02)	0.03 (0.01)	0.01 (0.00)	0.00 (0.00)
Sadness	0.27 (0.03) **	0.24 (0.03) *	0.15 (0.02)	0.07 (0.01)	0.03 (0.01)	0.02 (0.01)	0.01 (0.00)
Surprise	0.22 (0.04) †	0.24 (0.03) *	0.30 (0.03) ***	0.42 (0.03) ***	0.36 (0.03) ***	0.27 (0.03) **	0.14 (0.03)
Expression of Happiness							
Anger	0.08 (0.02)	0.06 (0.01)	0.03 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)
Disgust	0.16 (0.03)	0.17 (0.03)	0.07 (0.02)	0.04 (0.01)	0.03 (0.01)	0.01 (0.01)	0.01 (0.01)
Fear	0.07 (0.01)	0.06 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.00)	0.00 (0.00)	---
Happiness	0.39 (0.04) ***	0.47 (0.05) ***	0.74 (0.04) ***	0.91 (0.02) ***	0.94 (0.02) ***	0.98 (0.01) ***	0.97 (0.01) ***
Sadness	0.16 (0.03)	0.11 (0.03)	0.04 (0.02)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Surprise	0.15 (0.03)	0.13 (0.03)	0.08 (0.02)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	---
Expression of Sadness							
Anger	0.09 (0.02)	0.12 (0.02)	0.13 (0.02)	0.21 (0.02) *	0.12 (0.02)	0.02 (0.01)	0.01 (0.01)
Disgust	0.15 (0.02)	0.18 (0.02)	0.20 (0.02) *	0.18 (0.02)	0.16 (0.02)	0.04 (0.01)	0.01 (0.00)
Fear	0.11 (0.02)	0.11 (0.02)	0.10 (0.02)	0.12 (0.02)	0.12 (0.02)	0.08 (0.02)	0.05 (0.01)
Happiness	0.18 (0.03)	0.12 (0.02)	0.11 (0.02)	0.07 (0.01)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)
Sadness	0.31 (0.03) ***	0.31 (0.03) ***	0.29 (0.03) ***	0.30 (0.03) ***	0.54 (0.04) ***	0.83 (0.02) ***	0.91 (0.02) ***
Surprise	0.16 (0.03)	0.17 (0.03)	0.17 (0.04)	0.13 (0.03)	0.06 (0.01)	0.02 (0.01)	0.01 (0.00)
Expression of Surprise							
Anger	0.07 (0.01)	0.06 (0.01)	0.03 (0.01)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	---
Disgust	0.13 (0.02)	0.10 (0.01)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Fear	0.12 (0.02)	0.11 (0.02)	0.08 (0.02)	0.04 (0.01)	0.05 (0.01)	0.05 (0.02)	0.07 (0.02)
Happiness	0.15 (0.02)	0.11 (0.02)	0.05 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	---
Sadness	0.19 (0.03)	0.16 (0.03)	0.04 (0.01)	0.01 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)
Surprise	0.34 (0.04) ***	0.46 (0.05) ***	0.78 (0.03) ***	0.92 (0.01) ***	0.93 (0.02) ***	0.94 (0.02) ***	0.91 (0.02) ***

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

General Discussion

The intent of the current thesis was to further investigate the JACBART paradigm by exploring the role of various experimental design manipulations. The factors examined included: 1) The effect of varying the forward mask, 2) The effect of including (or not) a 'neutral' response option, and 3) The effect of reducing the intensity of the facial expressions presented. Because the JACBART is proposed as a standard method for determining the ability of individuals to recognize micro-expressions, it is important to understand the effects of factors such as these, which may affect the validity of its results.

Study 1 was designed to examine the potential anticipatory effects that may result from a fixed-duration forward mask. Previous studies (e.g., Coul & Nobre, 1998; Nobre & Van Ede, 2018) have demonstrated that observers are capable of learning to anticipate the onset of a target if primes contain temporal information, thereby facilitating target recognition. Because a fixed-duration forward mask in the JACBART would act as a prime containing temporal information, and because the forward mask in the paradigm is commonly administered with a fixed duration (e.g., Matsumoto & Hwang, 2011; Shen et al., 2012; Zhang et al., 2014) or a duration that varies by a maximum of 67 ms (e.g., Hall & Matsumoto, 2004; Hurley, 2012; Hurley et al., 2014; Matsumoto et al., 2000), it is possible that the standard task over-estimates the ability of participants to recognize micro-expressions. This study also acted as a preliminary investigation of the emotion classification at brief durations by exploring the duration required for accurate classification to exceed chance (i.e., the necessity threshold) and the duration required for a micro-expression to produce classification rates equivalent to a macro-expression (i.e., the efficiency threshold).

Study 2 was designed to examine a different methodological aspect of the JACBART paradigm. Specifically, it was aimed at understanding the effect of including (or not) a ‘neutral’ response option. Although the paradigm was originally proposed as a forced-choice task that exclusively included the emotional labels for the expressions presented in the task (Matsumoto et al., 2000; see also Shen et al., 2012), later administrations have commonly included additional ‘none of the above’ and/or ‘neutral’ options (e.g., Hurley, 2012; Hurley et al., 2014; Matsumoto & Hwang, 2011). The rationale for this decision is based on the work by Frank and Stennett (2001), which showed that the inclusion of ‘none of these terms are correct’ option reduces artifactual agreement on erroneous emotion labels. However, generalizing Frank and Stennett’s work to the JACBART was somewhat speculative, as their findings did not arise from brief facial expressions of emotion. Rather, their participants were given as much time as needed to classify the expression. Nevertheless, the inclusion of a ‘neutral’ option has theoretical value in the JACBART, as it is a dual-task that requires an observer to detect and classify the emotion. Considering the brief nature of the targets in this paradigm, emotion detection difficulty would be expected to increase as target duration decreases. As such, a ‘neutral’ option was hypothesized to reduce artifactual agreement in cases where the observer has difficulty detecting the emotion.

Finally, Study 3 was designed to examine the role of expression intensity. Micro-expressions are suggested to be largely portrayed as subtle expressions (Porter & ten Brinke, 2008; Yan et al., 2013). This may include less intense and/or partial presentations of the expression in the eye or mouth region. Despite this evidence, classification rates with the JACBART have not been assessed with low intensity expressions. Indeed, such expressions have received very little attention in emotion recognition literature (Matsumoto & Hwang, 2014).

Study Summaries

Study 1

Individuals performed equally well (i.e., within the estimated margin of error) when the duration of the forward mask was allowed to vary (i.e., between 750 and 1250 ms) compared to when its duration was fixed at 1000 ms. As such, despite the evidence that individuals can learn to anticipate target onset (Coull & Nobre, 1998; Nobre & Van Ede, 2018), the current findings suggest a fixed-duration forward mask may not facilitate accurate emotion classification in a JACBART paradigm.

Assessments of the classification performance rates demonstrated the integral roles of the target's emotion and presentation duration in the JACBART paradigm. The classification of happiness and surprise expressions exceeded chance with durations as brief as 17 ms. Conversely, longer durations were needed for the classification of anger, fear, and sadness expressions to exceed chance. In addition, despite there being no significant overall difference between variable-duration and fixed-duration groups, classification of disgust exceeded chance with as brief as 17 ms with a fixed-duration forward mask but required 67 ms with a variable-duration forward mask. Taken together, these things suggest that the necessity threshold may be below 17 ms with expressions of happiness and surprise, but expressions of anger, disgust, fear, and sadness may require durations between 17 and 67 ms for classification rates to exceed chance.

Finally, as a rough measure of the upper limit duration (i.e., the efficiency threshold, or the presentation duration sufficient to achieve recognition performance equivalent to unlimited viewing), classification rates were compared between micro-expression durations (i.e., 17 and 67 ms) and macro-expression durations (i.e., 500 ms). The efficiency threshold is suggested to fall somewhere between 17 and 67 ms for expressions of anger and surprise, as 67 ms was sufficient for classification rates to be equivalent to those produced with a 500 ms duration. Conversely, 67 ms was not sufficient for the remaining expressions to achieve ceiling level performance, suggesting their efficiency thresholds likely fall somewhere between 67 and 500 ms.

Study 2

The presentation of a ‘neutral’ option in the JACBART paradigm had a negative impact on classification performances with target expressions presented for durations of 40 ms or less, except with expressions of anger and fear. However, the extent of this effect varied across emotions. With durations of 40 ms or less, disgust and sadness expression classification rates were consistently greater for those without a ‘neutral’ option compared to those with a ‘neutral’ option. Conversely, the presentation of a ‘neutral’ option only respectively impacted happy and surprise expression classification rates with durations up to 10 and 20 ms.

These findings align with the observation of a ‘neutral’ response bias with expressions presented for durations between 5 and 40 ms. That is, participants were increasingly biased towards choosing the ‘neutral’ response option as stimulus presentation time decreased. This finding may be taken to demonstrate the dual-task nature of the JACBART, as it may represent participants’ increased difficulty detecting the emotion (i.e., as a necessary step prior to classifying it) with very brief durations. However, this bias was not consistent across emotions. Our data suggests there may be more difficulty detecting expressions of emotion of a negative valence (i.e., anger, disgust, fear, and sadness) compared to happiness and surprise expressions with a 5 ms duration. Conversely, with durations between 10 and 40 ms, respondents demonstrated the greatest difficulty detecting expressions of anger and sadness, and the least difficulty with expressions of happiness and surprise.

The assessment of thresholds demonstrated similar trends. First, the chance threshold was explored to determine the minimum duration required for classification performance to exceed chance-level performance. A minimum of 20 ms was required for fear expression classification to exceed chance regardless of the 'neutral' option, and a minimum of 5 ms was required for happiness and surprise. Conversely, chance threshold differences between conditions with and without a 'neutral' response option were observed with expressions of anger, disgust, and sadness. A minimum of 40 ms was required for classification rates to exceed chance when the 'neutral' option was provided with these expressions, whereas shorter durations are required for classification rates to exceed chance when the 'neutral' option was not provided in a forced-choice paradigm—as the chance threshold was 20 ms for expressions of anger and 5 ms for expressions of disgust and sadness. Taken together, these findings demonstrate the impact of a forced-choice paradigm on chance level classification of brief expressions of emotion. The observed inflation of classification rates when a 'neutral' option is provided may be indicative of strategic guessing behaviours when emotion detection and classification is more difficult.

Finally, psychometric thresholds were assessed by predicting the duration required for observers to effectively classify the expressions. The durations required for classification rates to reach this theoretical threshold (i.e., 58%) varied across emotions. Expressions of anger, fear, and sadness are respectively predicted to meet this threshold at approximate durations of 60, 40, and 50 ms regardless of the presentation of a 'neutral' option. Conversely, far briefer durations were required for expressions of happiness and surprise (~10 ms). Finally, the disgust expression psychometric thresholds demonstrated the largest effect of the force-choice paradigm, as the classification rate was predicted to meet the theoretical threshold with a duration 36 ms briefer than when a 'neutral' option was provided.

Study 3

The lower intensity 50% expressions were observed to negatively impact classification performances compared to the 100% intensity expression with all expressions except disgust. However, the nature of this effect varied across emotions and durations. For instance, expression intensity was observed to primarily affect happiness and surprise classification with brief durations of 20 ms and less. Conversely, the effect of intensity was observed with durations of 20 ms and greater for expressions of fear, while sadness and anger expressions demonstrated signs of this effect in the mid-range micro-expression durations (i.e., 40 to 160 ms with expressions of sadness and 80 ms with expressions of anger).

These results align with the predicted psychometric threshold durations, as shorter durations were required for effective classification of happiness and surprise (~ 10 ms) compared to negative expressions (i.e., anger, disgust, fear, and sadness; all > 30 ms). In addition, though little difference was observed between psychometric thresholds for the 100% and 50% intensity disgust expressions (i.e., $\Delta = 12$ ms), the remaining negative expressions displayed larger effects of intensity (i.e., $\Delta_{\text{Anger}} = 57$ ms, $\Delta_{\text{Fear}} = 62$ ms, $\Delta_{\text{Sadness}} = 43$ ms).

Individuals demonstrated a sensitivity to the emotions in the JACBART paradigm, as performances exceeded chance with durations as brief as 5 ms. However, respondents also demonstrated a general response bias away from the ‘anger’ option, with the most common exception being with fear expressions. This aligns with chance classification rates, where longer durations were required for accurate anger and fear classification to exceed chance—as a minimum of 20 and 40 ms was respectively required for 100% and 50% expressions—compared to the remaining expressions of emotion that exceeded chance at approximately 5 ms regardless of expression intensity.

Implications

In social interactions, the human face provides a rich source of information which an observer will use to make a variety of judgements, including: age (e.g., Hummert, 2014, Rhodes & Anastasi, 2012), gender or sex (e.g., Little et al., 2008, Thornhill & Gangestad, 2006), race or ethnicity (e.g., O'Toole et al., 1994, Tanaka et al., 2004), individual identity (e.g., Gauthier et al., 1999, Haxby et al., 2000), attractiveness (e.g., Perrett et al., 1998, Rhodes, 2006), sexual orientation (e.g., Freeman et al., 2010, Tskhay et al., 2013), and emotional state (e.g., Ekman et al., 1969). This complex facial information is often ascertained through individual or a combination of features (e.g., morphology or movements). Indeed, Schyns and Oliva (1999) demonstrated that the recognition of identity, gender, and emotion relied on varying spatial frequency information.

Ekman and Friesen (1978) developed the FACS as a comprehensive tool to decode features commonly involved in the expression of specific emotions, including facial muscle movements, head movements, and eye movements. These compositions were later confirmed by observers commonly using the anticipated response choices in affect recognition tasks (Gosselin et al., 1995). However, the expression of emotion is not solely dependent on the composition of facial muscles. Indeed, the portrayal of an emotion is complex (Matsumoto & Hwang, 2014), including facial composition, muscle intensity (Calvo et al., 2016; Hess et al., 1997; Hoffmann et al., 2010; Matsumoto & Hwang, 2014; Palermo & Coltheart, 2004), and a variety of temporal dynamics (i.e., onset, apex, and offset; e.g., Bugental, 1986; Cohn & Schmidt, 2004; Frank et al., 1993; Hess et al., 1989; Hess & Kleck, 1990; Horic-Asselin et al., 2020; Krumhuber & Kappas, 2005; Schmidt et al., 2001, 2006, 2009; Weiss et al., 1987). An example of this complexity can be observed in micro-expressions.

The recognition of micro-expressions is commonly thought to be important, as it reflects a true representation of an individual's emotions that is independent from the individual's conscious control (see Ekman, 2003). However, recognition is made difficult by their brief portrayals, between 40 and 500 ms (Frank et al., 1993; Paul Ekman Group, n.d.; Matsumoto & Hwang, 2018; Yan et al., 2013). For this reason, literature has primarily expressed interest in training, as it has important implications in high-stake situations (e.g., Matsumoto et al., 2014) and clinical interventions (e.g., Marsh et al., 2010; Russell et al., 2006; Russell et al., 2008). However, to understand the effects of training, a standardized measure of brief affect recognition was first needed. Matsumoto and colleagues (2000) proposed the JACBART as this standardized measure.

The current studies demonstrate some of the various factors that can influence JACBART performance. That is, although there was little evidence that anticipatory effects with a fixed-duration forward mask would facilitate task performance, there was evidence that the presentation of a 'neutral' option and lower intensity expressions had a negative effect on performances. The circumstances of these effects across varying expression durations and emotions provide some interesting implications.

Firstly, with reduced classification performances and a bias for the 'neutral' option over emotion labels with expression durations of 40 ms and less, the current findings support the hypothesis that the JACBART is a dual-task paradigm that requires both (1) the discrimination of the target emotion from the neutral expression masks and (2) the classification of said emotion—as it suggests expression discrimination becomes increasingly difficult with shorter expression durations. However, at durations of 40 ms and less, the expressions are falling below the lower limit of what is theoretically considered to constitute a micro-expression (i.e., 40 ms; Ekman &

Friesen, 1975). Indeed, empirical evidence suggests the minimum duration of a micro-expression may be around 169 ms, and the minimum micro-expression onset may only begin approximately 66 ms after an emotional event (Yan et al., 2013). As such, discrimination difficulties may not play a large role in real-life scenarios with micro-expression durations greater than 40 ms. Nevertheless, the current findings have important implications for studies that intend to explore recognition with extremely brief durations—as the exclusion of a 'neutral' option may result in an increased rate of unintended strategic response behaviours. Conversely, with expression durations greater than 40 ms, there is little evidence to suggest that a 'neutral' option is needed in the JACBART paradigm.

Unlike the effect of the 'neutral' option, current results suggest expression intensity affected classification performance with durations up 500 ms. With empirical evidence that micro-expressions are often portrayed as subtle expressions (Porter et al., 2008), the current findings address the staggering gap in the literature and present relevant information for better understanding how micro-expressions may be classified when they are not presented with a 100% intensity. Although research has suggested that a minimum intensity of 50% is required for all emotion classification performances to exceed the psychometric chance threshold (Calvo et al., 2016), current findings demonstrate a 50% intensity maintains its sufficiency with brief expressions of emotion. Furthermore, intensity interestingly demonstrated an effect on classification near the theoretical psychometric threshold (i.e., 58%) for all expressions of emotion, except disgust. These shifts in the position of the theoretical threshold are indicative of the increased difficulty with brief 50% intensity expressions. However, with all emotions except fear, the data also suggests that 50% intensity expressions reach classification rates comparable to their 100% intensity counterparts within the micro-expression time window. This further demonstrates the efficiency with which brief facial expressions are classified. Indeed, intensity did not affect the classification of happiness and surprise expressions with durations greater than 20 ms.

In spite of the brevity of the current facial expressions of emotions and the various JACBART design manipulations, happy and surprised expressions were commonly recognized quite effectively and at higher rates than other emotions. An advantage for happy recognition is not uncommon in emotion recognition research (see Nummenmaa & Calvo, 2015). Calvo and colleagues (2014) posited that happy expressions may demonstrate a recognition advantage because they are more frequently observed in social settings than expressions of other emotions (i.e., the frequency of occurrence hypothesis). However, this hypothesis cannot account for the high recognition performances with surprise—as the frequency of surprised expressions was previously not observed to differ from those of sadness or anger (Calvo et al., 2014). Conversely, two alternative hypotheses may better account for the advantages with expressions of happiness and surprise.

First, the diagnostic value hypothesis posits that key distinctive features (e.g., a big open smile) may benefit emotion recognition (Calvo & Nummenmaa, 2008). As happy and surprised expressions both provide more visually salient information in the mouth region, respondents may rely on these features to facilitate their emotion categorization. Conversely, the remaining expressions of emotion are generally distinguished from each other by relatively subtle eye and eye-brow differences or less visually salient mouth information. Finally, the affective uniqueness hypothesis posits that the increased difficulty with negative expressions (i.e., anger, disgust, fear, and sadness) is resulting from their shared affective value (Mendolia, 2007). Conversely, happy and surprised expressions would not observe the same level of interference because their affective values are unique and respectively represent positive and ambiguous emotions.

As it generally understood that it takes roughly 175-200 ms to initiate a saccade (i.e., locate a new visual target and initiate an eye movement; see Rayner, 2009, for a review), it is unlikely observers would be able to fixate more than two locations in a micro-expression with a duration less than 500 ms. Indeed, with all expression durations in the current thesis except 500 ms, observers would likely only have time to fixate on one location. Literature suggests the accurate recognition of macro-expressions often requires fixations in both the eyes/brows and mouth regions (i.e., configural or global information is required; e.g., Beaudry et al., 2014; Jack & Schyns, 2017). As such, observers would need to rely more on low spatial frequency information that can be obtained quickly and parafoveally. This would be consistent with Schyns and Oliva (1999), as they reported a bias for low spatial frequency information in an emotion categorization task. This low spatial information would be sufficient for the processing of the salient mouth regions in happy and surprised expressions and allow an observer to deduce that the expression's affective value is not negative. Though some information can be drawn from the erroneous response rates (see study 2), the current studies were not designed to address these two hypotheses.

The current studies instead present some methodological considerations for the measure of brief affect recognition in a JACBART paradigm. As micro-expression training programs are often focused on 100% intensity expressions presented for 67 ms or greater (e.g., Hurley, 2012; Hurley et al., 2014; Matsumoto & Hwang, 2011; Matsumoto et al., 2014), the inclusion of a 'neutral' option should not have a significant impact on affect recognition rates. In addition, study 1 suggests it may not be of concern that previous training literature has not used a variable-duration forward mask to offset stimulus onset anticipation. However, the effect of intensity may be problematic for micro-expression training studies, as the effect was observed to vary across emotions. As such, training programs using a 67 ms target duration could expect reduced performances with lower intensity expressions of anger, fear, and sadness.

Limitations and Future Research

Although the current evidence suggests a fixed-duration forward mask may not facilitate affect recognition through target onset anticipation, it could be argued that the variability used in the current study (i.e., 500 ms) may not be large enough to demonstrate an effect. Future research is needed to confirm if a larger range for the forward mask's duration (e.g., 500 to 3000 ms) would reduce affect recognition rates, thereby demonstrating that anticipatory effects were still observed with the 720 to 1250 ms range. Alternatively, event-related potentials could be assessed with the JACBART paradigm to determine if there are neural signs of target onset anticipation (e.g., contingent negative variation; see Nobre & van Ede, 2018).

As discussed by Breitmeyer and Öğmen (2006), forward and backward masking effectiveness may be related to the ratio between the mask and target stimuli (i.e., mask:target) durations. Although this is inconsistent with evidence that the duration of a backward mask has no additional effect on affect categorization after 30 ms (Esteves & Ohman, 1993), it should be noted that the current backward mask duration (i.e., 1000 ms) provides larger mask:target ratios than what was previously tested. As such, with target durations ranging from 5 to 500 ms (i.e., mask:target ratios from 200:1 to 2:1, respectively), this may suggest that the observed differences across target durations were to some degree influenced by the mask:target ratios. More specifically, the backward mask may be expected to have a stronger masking effect with the 5 ms target duration than the 500 ms target duration. Further research will be needed to explore the influence varying mask:target ratios on backward masking effectiveness in an affect categorization task.

As for the variable-duration forward masks (i.e., between 750 and 1,250 ms), the mask:target ratios would have a larger range with the 5 ms target duration (i.e., between 150:1 and 250:1) as compared to the 500 ms target duration (i.e., between 1.5:1 and 2.5:1). Indeed, it is unclear whether forward mask effectiveness would vary more with the shorter target durations. As such, further analyses will be needed to determine the role of these ratios in predicting affect categorization performance.

In spite of the fact that all participants had been specifically instructed in studies 1 and 2 that the 'neutral' option should be used to indicate if they did not see an emotion, some respondents may have strategically used the 'neutral' option when they were not confident in an emotion category. As such, the use of this option may be mixed with "I do not know" responses. It was for this reason that the 'neutral' option was excluded for the evaluation of the psychometric functions for 50% intensity expressions[6]. Future research will be needed to ascertain the extent to which the use of the 'neutral' option reflects emotion categorization confidence as opposed to emotion detection difficulty.

The current expressions are only taken from the JACFEE database of images, as they are the images commonly employed in a JACBART (e.g., Matsumoto et al., 2000; Matsumoto & Hwang, 2011). These images were FACS coded, and reliability testing suggests respondents overwhelmingly used the anticipated emotion categories to label the emotions depicted in the images (see Biehl et al., 1997). Nevertheless, they only represent a small sample of images.

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[6] Psychometric thresholds for 50% intensity expressions were also examined when a 'neutral' option was provided (see Appendix A). Its inclusion presented minimal changes to the locations of the psychometric thresholds as compared to when the 'neutral' option was excluded with 50% intensity expressions (all $|\Delta| < 24$ ms).

Future research may therefore consider testing brief affect recognition with different image databases. Similarly, the current thesis created 50% intensity expressions by using the mid-point between an emotion image and a neutral image. Though these images would theoretically depict scenarios where all facial AUs are reduced by 50%, they are not true lower intensity expressions. Instead, future research may consider using a stimulus database that consists of images that are FACS coded to present different intensity expressions. For instance, two expressions may consist of the same facial actions but at very different intensities.

The current thesis opted for the use of static stimuli, as this is common practice with the JACBART paradigm. However, this substitutes ecological validity for manipulation control. As such, the current results can only be used to inform our understanding of brief affect expression recognition and cannot be assumed to represent the categorization of dynamic expressions of emotion. Future studies are therefore needed to understand how the current results differ from those with dynamic expressions. This will however require further empirical study of micro-expressions, as the rate of intensity change at onset and offset is still largely unknown (see Yan et al., 2013).

Although all participants in the current thesis were required to have normal or corrected-to-normal vision, visual acuity was not directly measured. Prior literature has demonstrated that individuals with low vision have more difficulty correctly categorizing facial expressions of emotion (Johnson et al., 2017). However, as brief expressions would allow little time for the analysis of high spatial frequency information in the face, visual acuity may not have as strong an effect in a brief affect recognition task. Further research is required.

Conclusions

In conclusion, the current thesis explored the impacts of various JACBART design factors on affect recognition performance, including: 1) A forward mask with a variable duration, 2) The inclusion/exclusion of a ‘neutral’ response option, and 3) Expressions portrayed at lower intensities. Current findings indicate a variable-duration forward mask does not have a significant effect on affect recognition performance. Conversely, significant effects were observed for the inclusion of a ‘neutral’ response option and when reducing the expression intensity. Expressions of happiness and surprise also demonstrated a recognition advantage across all three studies. Recognition of these two expressions exceeded the psychometric threshold with durations of as little as 5 to 10 ms, while negative emotions (i.e., anger, disgust, fear, and sadness) required presentation times up to 113 ms for above-threshold recognition rates. In sum, the current findings expand our understanding of the various factors that may impact the temporal dynamics of affect recognition in the JACBART paradigm and present some methodological considerations for studies interested in measuring brief affect recognition.

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Appendix A – Subtle Expression Recognition with a Neutral Option

To ensure the current research was exercising its due diligence, a brief study was conducted to determine the effect of the 'neutral' option in a modified JACBART paradigm presenting subtle expressions with a 50% intensity. The materials and procedure were taken directly from study 3, but the additional 'neutral' option implemented in study 2 was provided. A total of 30 participants (6 males, 24 females; $M_{\text{age}} = 19.30$, $SD = 2.73$) were recruited to view the 50% intensity expressions.

Hit rates were analyzed in a 6 (Target Emotion: Anger, Disgust, Fear, Happiness, Sadness, and Surprise) × 7 (Target Duration: 5, 10, 20, 40, 80, 160, and 500 ms) repeated-measures ANOVA (see Table A1). Results demonstrate a significant interaction between the emotion and duration with the 50% intensity expressions, with better performances for expressions of happiness and surprise compared to the remaining expressions at very brief durations (i.e., 40 ms and less; see Table A2). Indeed, happiness and surprise recognition performances reached the theoretical psychometric chance threshold (i.e., 58%) with durations of approximately 17 ms (see Figure A1). Conversely, more than 80 ms was needed with 50% intensity expressions of anger, disgust, and fear.

When the effect of the 'neutral' option was explored, differences between unbiased and biased *d*' estimates suggest a significant response bias affected sensitivity during the JACBART paradigm when durations were very brief (i.e., 40 ms and less; see Figure A2). Indeed, respondents demonstrated a significant bias for the 'neutral' option (i.e., away from all other response options) when durations were below 80 ms (see Figure A2). In addition, a bias for the 'neutral' option was also observed with the 80 ms duration when compared to the 'anger', 'sadness', and 'fear' response options.

Finally, the locations of the theoretical psychometric threshold for 50% intensity expressions with a 'neutral' option are compared to those for 50% intensity expressions without a 'neutral' option in study 3. Interestingly, the inclusion of a 'neutral' option appears to have had little effect on the duration required for performance to reach the theoretical threshold with expressions of anger (Δ = -11 ms), disgust (Δ = -1 ms), fear (Δ = 23 ms), happiness (Δ = 3 ms), sadness (Δ = -7 ms), and surprise (Δ = 3 ms).

Table A1

Repeated-Measures ANOVA for Hit Rates for 50% Intensity Expressions Presented with a Neutral Option, including Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Target Durations (500, 1000, and 2000 ms) as Within-Subject Variables.

	df	*F*	η^2_G
Target Emotion	3.46, 100.22	130.86 ***	.52
Target Duration	2.44, 70.66	581.52 ***	.78
Target Emotion × Target Duration	9.27, 268.74	26.52 ***	.27

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Figure A1

Mean Hit Rates for Each 50% Intensity Expression (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Target Duration (5, 10, 20, 40, 80, 160, and 500 ms) with a 'Neutral' Option. Error Bars are Two Standard Error.

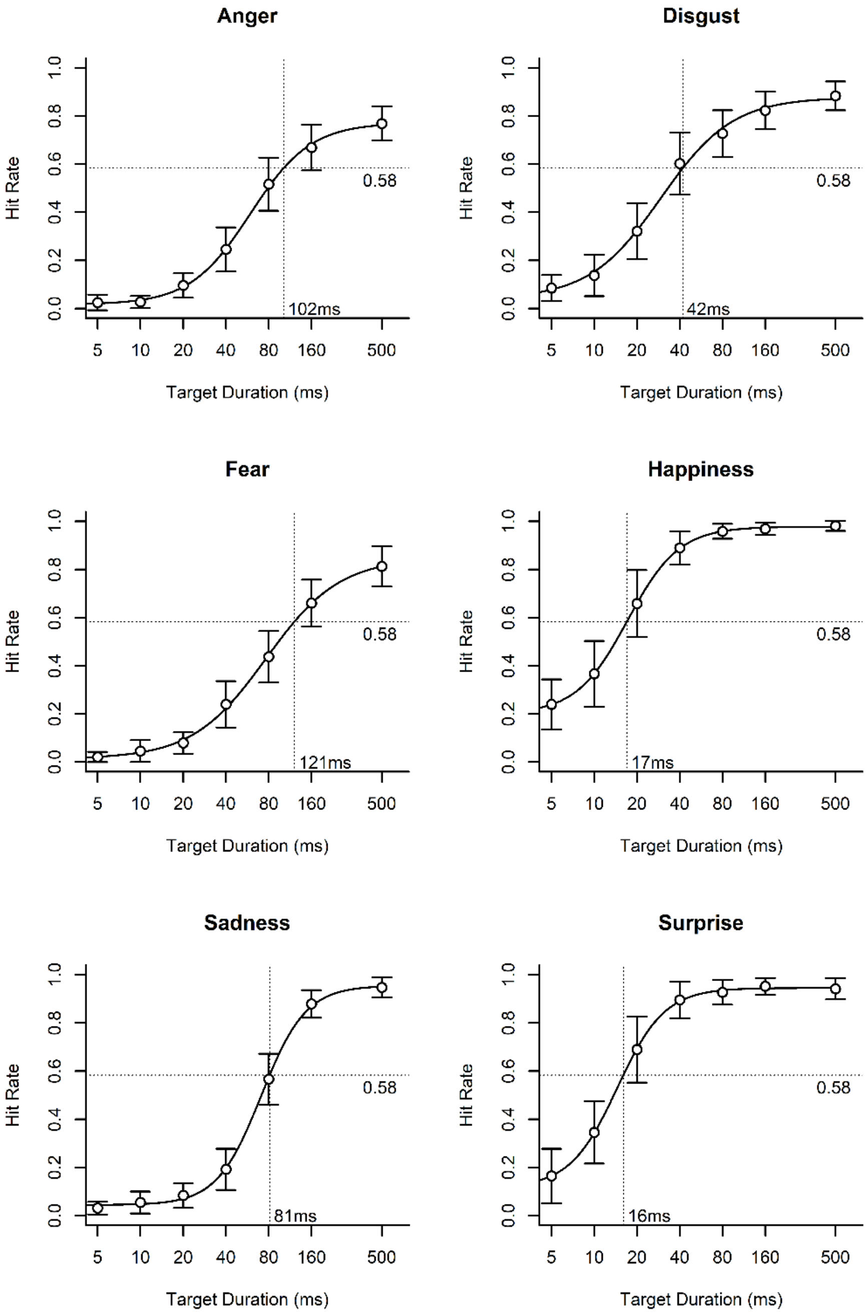

Figure A2

Unbiased (dashed) and Biased (solid) d’ Estimates. Response Biases for Anger (red), Disgust (green), Fear (purple), Happiness (yellow), Sadness (blue), and Surprise (cyan) Options when Compared to Neutral. Error Bars Represent 95% Confidence Intervals.

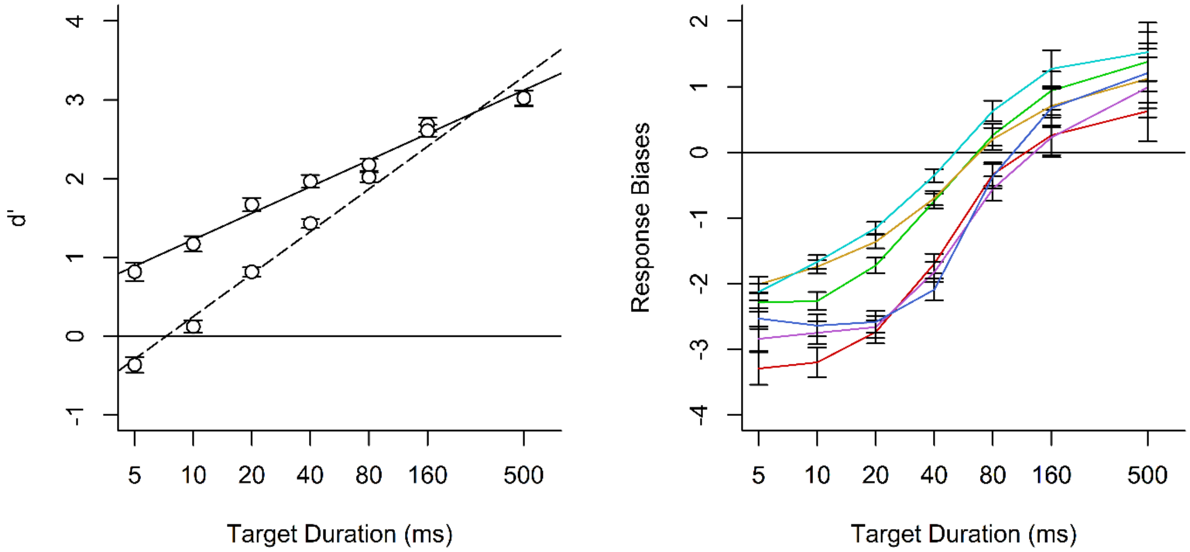

Table A2

Mean Response Rates (Standard Error) Compared to Chance (16.67 ms) for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) and Durations (5, 10, 20, 40, 80, 160, and 500 ms) Presented at 50% Intensity with a Neutral Option.

Response	5 ms	10 ms	20 ms	40 ms	80 ms	160 ms	500 ms
Expressions of Anger							
Anger	0.03 (0.01)	0.03 (0.01)	0.10 (0.02)	0.25 (0.03) *	0.52 (0.04) ***	0.67 (0.03) ***	0.77 (0.03) ***
Disgust	0.04 (0.01)	0.04 (0.02)	0.14 (0.03)	0.27 (0.04) **	0.25 (0.03) **	0.20 (0.03) †	0.16 (0.02)
Fear	0.02 (0.01)	0.02 (0.01)	0.03 (0.01)	0.03 (0.01)	0.04 (0.01)	0.03 (0.01)	0.02 (0.01)
Happiness	0.04 (0.01)	0.06 (0.02)	0.05 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.00)	---
Sadness	0.04 (0.01)	0.05 (0.01)	0.05 (0.01)	0.06 (0.01)	0.09 (0.02)	0.06 (0.01)	0.04 (0.01)
Surprise	0.01 (0.01)	0.04 (0.01)	0.03 (0.01)	0.03 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)
Neutral	0.83 (0.04) ***	0.77 (0.05) ***	0.61 (0.06) ***	0.33 (0.05) **	0.06 (0.02)	0.01 (0.00)	0.01 (0.00)
Expressions of Disgust							
Anger	0.01 (0.01)	0.03 (0.01)	0.05 (0.01)	0.11 (0.03)	0.13 (0.03)	0.12 (0.03)	0.07 (0.02)
Disgust	0.09 (0.02)	0.14 (0.03)	0.32 (0.04) ***	0.60 (0.05) ***	0.73 (0.03) ***	0.82 (0.03) ***	0.88 (0.02) ***
Fear	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.04 (0.01)	0.04 (0.01)	0.03 (0.01)	0.04 (0.01)
Happiness	0.06 (0.02)	0.05 (0.01)	0.08 (0.01)	0.09 (0.01)	0.06 (0.01)	0.00 (0.00)	0.00 (0.00)
Sadness	0.05 (0.02)	0.03 (0.01)	0.03 (0.01)	0.01 (0.01)	0.02 (0.01)	0.01 (0.00)	0.01 (0.00)
Surprise	0.04 (0.01)	0.07 (0.02)	0.04 (0.01)	0.03 (0.01)	0.01 (0.00)	0.00 (0.00)	---
Neutral	0.73 (0.05) ***	0.66 (0.06) ***	0.45 (0.06) ***	0.11 (0.03)	0.02 (0.01)	0.01 (0.01)	---
Expressions of Fear							
Anger	0.01 (0.00)	0.02 (0.01)	0.02 (0.01)	0.01 (0.00)	0.01 (0.00)	---	---
Disgust	0.05 (0.02)	0.04 (0.01)	0.04 (0.01)	0.06 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)
Fear	0.02 (0.01)	0.05 (0.02)	0.08 (0.02)	0.24 (0.03) *	0.44 (0.04) ***	0.66 (0.03) ***	0.81 (0.03) ***
Happiness	0.03 (0.01)	0.06 (0.01)	0.05 (0.01)	0.06 (0.01)	0.03 (0.01)	0.01 (0.00)	---
Sadness	0.06 (0.01)	0.04 (0.01)	0.05 (0.01)	0.03 (0.01)	0.05 (0.01)	0.02 (0.01)	0.01 (0.01)
Surprise	0.06 (0.02)	0.10 (0.03)	0.22 (0.04) †	0.40 (0.04) ***	0.42 (0.03) ***	0.28 (0.03) ***	0.16 (0.03)
Neutral	0.78 (0.05) ***	0.71 (0.05) ***	0.54 (0.06) ***	0.21 (0.04)	0.04 (0.01)	0.01 (0.01)	0.01 (0.00)
Expressions of Happiness							
Anger	0.02 (0.01)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)
Disgust	0.04 (0.01)	0.05 (0.02)	0.04 (0.01)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)	---
Fear	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.00)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)
Happiness	0.24 (0.04) *	0.37 (0.05) ***	0.66 (0.05) ***	0.89 (0.02) ***	0.96 (0.01) ***	0.97 (0.01) ***	0.98 (0.01) ***
Sadness	0.01 (0.00)	0.01 (0.01)	0.02 (0.01)	0.00 (0.00)	---	---	0.01 (0.00)
Surprise	0.06 (0.02)	0.07 (0.02)	0.06 (0.02)	0.03 (0.01)	0.01 (0.01)	---	---
Neutral	0.61 (0.05) ***	0.46 (0.06) ***	0.21 (0.05)	0.05 (0.02)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)
Expressions of Sadness							
Anger	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)	0.08 (0.02)	0.08 (0.01)	0.01 (0.01)	---
Disgust	0.06 (0.02)	0.05 (0.01)	0.09 (0.02)	0.13 (0.02)	0.11 (0.02)	0.04 (0.01)	0.01 (0.01)
Fear	0.03 (0.01)	0.04 (0.01)	0.03 (0.01)	0.05 (0.01)	0.06 (0.01)	0.04 (0.01)	0.03 (0.01)
Happiness	0.02 (0.01)	0.04 (0.01)	0.04 (0.01)	0.03 (0.01)	0.01 (0.01)	---	0.00 (0.00)
Sadness	0.03 (0.01)	0.05 (0.02)	0.08 (0.02)	0.19 (0.03)	0.57 (0.04) ***	0.88 (0.02) ***	0.95 (0.01) ***
Surprise	0.04 (0.01)	0.06 (0.02)	0.07 (0.02)	0.09 (0.02)	0.05 (0.01)	0.01 (0.01)	0.00 (0.00)
Neutral	0.81 (0.04) ***	0.75 (0.05) ***	0.66 (0.06) ***	0.43 (0.05) ***	0.12 (0.03)	0.02 (0.01)	0.00 (0.00)
Expressions of Surprise							
Anger	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)	---	---	0.00 (0.00)	---
Disgust	0.03 (0.01)	0.02 (0.01)	0.01 (0.00)	0.00 (0.00)	---	0.00 (0.00)	---
Fear	0.05 (0.01)	0.05 (0.01)	0.05 (0.01)	0.04 (0.01)	0.05 (0.01)	0.03 (0.01)	0.05 (0.02)
Happiness	0.05 (0.01)	0.05 (0.01)	0.04 (0.01)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.03 (0.01)	0.03 (0.01)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Surprise	0.16 (0.04)	0.35 (0.05) ***	0.69 (0.05) ***	0.90 (0.03) ***	0.93 (0.02) ***	0.95 (0.01) ***	0.94 (0.02) ***
Neutral	0.68 (0.06) ***	0.51 (0.06) ***	0.20 (0.05)	0.04 (0.02)	0.02 (0.01)	0.00 (0.00)	0.01 (0.00)

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Appendix B – Macro-Expression Recognition

In a brief study, expressions of emotion were displayed with longer durations (i.e., 500, 1000, and 2000 ms) using the Japanese and Caucasian Brief Affect Recognition Test (JACBART) to determine how recognition rates vary across emotion, duration, intensity, and response options. A total of 28 participants were recruited to participate in one of two Neutral Option groups, with 14 participants presented expressions with a 'neutral' (4 males, 10 females; $M_{\text{age}} = 18.86$, $SD = 1.75$) and 14 participants presented expressions without a 'neutral' option (2 males, 12 females; $M_{\text{age}} = 18.57$, $SD = 1.60$). Using the same materials applied in studies 2 and 3, expressions were presented in the following design: 6 Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise) × 2 Target Intensity (100% and 50%) × 3 Target Durations (500, 1000, and 2000 ms; i.e., 100, 200, and 400 frames on a 200 Hz monitor).

Results of the mixed-design ANOVA with hit rates suggest the presentation of a 'neutral' option did not have a significant effect with these longer expression durations (see Table B1). Conversely, an interaction was observed between emotion and intensity. Expressions of fear, happiness, and sadness demonstrated improved hit rates when presented at 100% intensity compared to 50% (all $p < .05$). Conversely, no such difference was observed with expressions of anger, disgust, or surprise. Although the effect of intensity was expected with expressions of fear and sadness based on the results of study 3, it was not expected with happiness. A review of the response matrix suggests happiness at a 50% intensity demonstrated increased confusion (see Table B2 and B3). This confusion may have occurred due to the increased time to evaluate the images and the ability to compare 100% and 50% expressions across trials. Finally, a significant interaction between emotion and duration suggests that only expressions of anger demonstrated continuous improvements in performance up to 2000 ms (both $p < .05$; see Figure B1). However, 2000 ms was observed to benefit the recognition of disgust relative to a 500 ms duration ($p < .05$).

Table B1

Mixed-Design ANOVAs for Hit Rates with Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise), Target Intensity (100% and 50%), and Target Durations (500, 1000, and 2000 ms) as Within-Subject Variables, and Neutral Option (with or without a Neutral Option) as a Between-Subject Variable.

	df	*F*	η_G^2
Neutral Option	1 26	0.03	
Expression Intensity	1 26	27.58 ***	0.02
Target Duration	2 52	18.22 ***	0.01
Target Emotion	2.98 77.60	12.30 ***	0.13
Expression Intensity × Neutral Option	1 26	1.21	
Expression Intensity × Target Duration	2 52	0.85	
Target Duration × Neutral Option	2 52	0.87	
Expression Intensity × Target Emotion	2.73 70.85	7.16 ***	0.03
Target Emotion × Neutral Option	2.98 77.60	0.66	
Target Emotion × Target Duration	10 260	6.59 ***	0.01
Expression Intensity × Target Duration × Neutral Option	2 52	0.24	
Expression Intensity × Target Emotion × Neutral Option	2.73 70.85	0.82	
Expression Intensity × Target Emotion × Target Duration	10 260	1.58	
Target Emotion × Target Duration × Neutral Option	10 260	0.55	
Expression Intensity × Target Emotion × Target Duration × Neutral Option	10 260	1.39	

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Figure B1

Hit Rates for Expressions of Anger (red), Disgust (green), Fear (purple), Happiness (yellow), Sadness (blue), and Surprise (cyan) with Macro-Expressions at Varying Durations and Intensities..

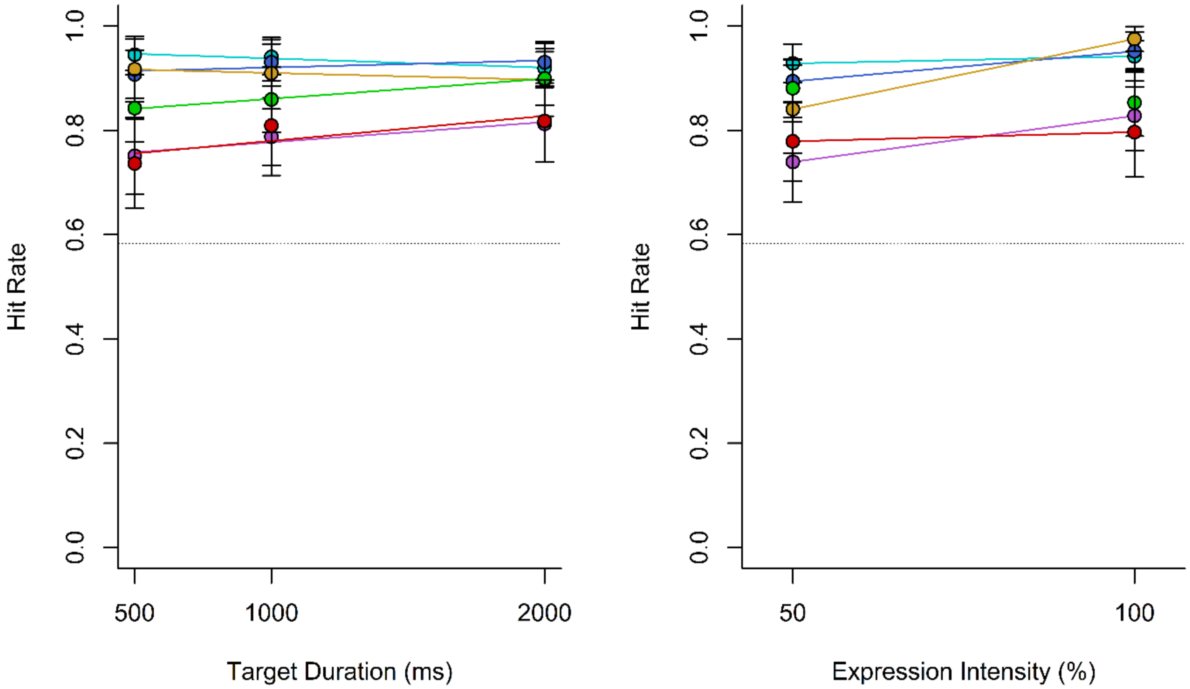

Table B2

Mean Response Rates (Standard Error) Compared to Chance (16.67 ms) for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise), Target Durations (5, 10, 20, 40, 80, 160, and 500 ms), and Target Intensities (100% and 50%) Presented without a Neutral Option.

	100% Expressions			50% Neutral Option		
Response	500 ms	1000 ms	2000 ms	500 ms	1000 ms	2000 ms
Expressions of Anger						
Anger	0.77 (0.03) ***	0.79 (0.03) ***	0.79 (0.03) ***	0.70 (0.03) ***	0.82 (0.03) ***	0.86 (0.02) ***
Disgust	0.21 (0.03) †	0.18 (0.03)	0.18 (0.03)	0.19 (0.03)	0.14 (0.02)	0.10 (0.02)
Fear	---	0.01 (0.01)	0.01 (0.01)	0.03 (0.01)	0.00 (0.00)	0.00 (0.00)
Happiness	0.01 (0.01)	0.01 (0.01)	---	0.01 (0.01)	---	0.00 (0.00)
Sadness	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.07 (0.02)	0.04 (0.01)	0.02 (0.01)
Surprise	0.00 (0.00)	---	0.01 (0.01)	---	---	0.01 (0.01)
Expressions of Disgust						
Anger	0.16 (0.02)	0.15 (0.02)	0.13 (0.02)	0.14 (0.02)	0.13 (0.02)	0.06 (0.02)
Disgust	0.83 (0.03) ***	0.81 (0.03) ***	0.85 (0.02) ***	0.83 (0.02) ***	0.83 (0.02) ***	0.92 (0.02) ***
Fear	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	---
Happiness	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	---	0.00 (0.00)	---
Sadness	---	0.02 (0.01)	---	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Surprise	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Expressions of Fear						
Anger	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	---	0.00 (0.00)	0.01 (0.01)
Disgust	0.04 (0.01)	0.04 (0.01)	0.04 (0.01)	0.04 (0.01)	0.04 (0.01)	0.02 (0.01)
Fear	0.80 (0.03) ***	0.85 (0.02) ***	0.89 (0.02) ***	0.72 (0.03) ***	0.75 (0.03) ***	0.75 (0.03) ***
Happiness	---	---	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)
Sadness	0.02 (0.01)	0.00 (0.00)	0.01 (0.01)	0.06 (0.02)	0.02 (0.01)	0.03 (0.01)
Surprise	0.12 (0.02)	0.11 (0.02)	0.06 (0.02)	0.16 (0.02)	0.17 (0.03)	0.18 (0.03)
Expressions of Happiness						
Anger	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.01)	0.02 (0.01)
Disgust	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.05 (0.02)
Fear	---	---	---	0.01 (0.01)	0.02 (0.01)	0.03 (0.01)
Happiness	0.98 (0.01) ***	0.98 (0.01) ***	0.98 (0.01) ***	0.89 (0.02) ***	0.89 (0.02) ***	0.85 (0.02) ***
Sadness	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.08 (0.02)	0.05 (0.02)	0.04 (0.01)
Surprise	---	0.00 (0.00)	0.00 (0.00)	0.02 (0.01)	0.00 (0.00)	0.00 (0.00)
Expressions of Sadness						
Anger	0.00 (0.00)	---	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)
Disgust	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.03 (0.01)	0.04 (0.01)	0.01 (0.01)
Fear	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.03 (0.01)	0.04 (0.01)	0.02 (0.01)
Happiness	0.00 (0.00)	---	0.02 (0.01)	0.01 (0.01)	---	0.02 (0.01)
Sadness	0.95 (0.02) ***	0.97 (0.01) ***	0.96 (0.01) ***	0.91 (0.02) ***	0.92 (0.02) ***	0.93 (0.02) ***
Surprise	0.01 (0.01)	0.00 (0.00)	---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Expressions of Surprise						
Anger	---	---	0.01 (0.01)	0.00 (0.00)	---	---
Disgust	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)
Fear	0.04 (0.01)	0.04 (0.01)	0.04 (0.01)	0.03 (0.01)	0.06 (0.02)	0.08 (0.02)
Happiness	---	0.01 (0.01)	---	---	0.00 (0.00)	0.01 (0.01)
Sadness	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.02 (0.01)
Surprise	0.94 (0.02) ***	0.93 (0.02) ***	0.94 (0.02) ***	0.95 (0.02) ***	0.92 (0.02) ***	0.88 (0.02) ***

† *p* < .10, * *p* < .05, ** *p* < .01, *** *p* < .001

Table B3

Mean Response Rates (Standard Error) Compared to Chance (16.67%) for all Target Emotions (Anger, Disgust, Fear, Happiness, Sadness, and Surprise), Target Durations (5, 10, 20, 40, 80, 160, and 500 ms), and Target Intensities (100% and 50%) Presented with a Neutral Option.

	100% Expressions			50% Neutral Option		
Response	500 ms	1000 ms	2000 ms	500 ms	1000 ms	2000 ms
Expressions of Anger						
Anger	0.76 (0.03) ***	0.84 (0.02) ***	0.82 (0.03) ***	0.71 (0.03) ***	0.78 (0.03) ***	0.79 (0.03) ***
Disgust	0.11 (0.02)	0.07 (0.02)	0.10 (0.02)	0.09 (0.02)	0.06 (0.02)	0.06 (0.02)
Fear	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)
Happiness	0.02 (0.01)	0.02 (0.01)	0.00 (0.00)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)
Sadness	0.04 (0.01)	0.03 (0.01)	0.02 (0.01)	0.03 (0.01)	0.04 (0.01)	0.03 (0.01)
Surprise	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	---
Neutral	0.04 (0.01)	0.01 (0.01)	0.03 (0.01)	0.12 (0.02)	0.09 (0.02)	0.09 (0.02)
Expressions of Disgust						
Anger	0.08 (0.02)	0.08 (0.02)	0.05 (0.02)	0.06 (0.02)	0.03 (0.01)	0.04 (0.01)
Disgust	0.85 (0.02) ***	0.88 (0.02) ***	0.90 (0.02) ***	0.86 (0.02) ***	0.91 (0.02) ***	0.93 (0.02) ***
Fear	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)
Happiness	0.02 (0.01)	0.00 (0.00)	---	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
Sadness	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.03 (0.01)	0.00 (0.00)
Surprise	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	---
Neutral	0.01 (0.01)	0.02 (0.01)	0.01 (0.01)	0.03 (0.01)	0.01 (0.01)	0.02 (0.01)
Expressions of Fear						
Anger	0.01 (0.01)	---	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	---
Disgust	0.03 (0.01)	0.02 (0.01)	0.02 (0.01)	0.03 (0.01)	0.04 (0.01)	0.01 (0.01)
Fear	0.79 (0.03) ***	0.80 (0.03) ***	0.83 (0.02) ***	0.68 (0.03) ***	0.75 (0.03) ***	0.78 (0.03) ***
Happiness	0.00 (0.00)	---	---	---	0.00 (0.00)	0.01 (0.01)
Sadness	0.03 (0.01)	0.02 (0.01)	0.03 (0.01)	0.08 (0.02)	0.06 (0.02)	0.05 (0.01)
Surprise	0.12 (0.02)	0.14 (0.02)	0.10 (0.02)	0.16 (0.02)	0.11 (0.02)	0.12 (0.02)
Neutral	0.01 (0.01)	0.02 (0.01)	0.00 (0.00)	0.04 (0.01)	0.03 (0.01)	0.03 (0.01)
Expressions of Happiness						
Anger	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.02 (0.01)	0.00 (0.00)
Disgust	0.00 (0.00)	---	0.01 (0.01)	0.01 (0.01)	0.04 (0.01)	0.04 (0.01)
Fear	0.00 (0.00)	---	---	0.01 (0.01)	0.04 (0.01)	0.02 (0.01)
Happiness	0.97 (0.01) ***	0.97 (0.01) ***	0.97 (0.01) ***	0.83 (0.03) ***	0.80 (0.03) ***	0.79 (0.03) ***
Sadness	---	0.01 (0.01)	0.00 (0.00)	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)
Surprise	---	0.00 (0.00)	0.00 (0.00)	---	---	0.01 (0.01)
Neutral	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.12 (0.02)	0.09 (0.02)	0.13 (0.02)
Expressions of Sadness						
Anger	0.00 (0.00)	0.00 (0.00)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)
Disgust	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	---
Fear	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)
Happiness	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	---	---	0.00 (0.00)
Sadness	0.95 (0.02) ***	0.95 (0.01) ***	0.93 (0.02) ***	0.83 (0.03) ***	0.88 (0.02) ***	0.90 (0.02) ***
Surprise	---	0.01 (0.01)	---	0.01 (0.01)	---	---
Neutral	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.13 (0.02)	0.09 (0.02)	0.08 (0.02)
Expressions of Surprise						
Anger	---	---	---	---	---	---
Disgust	---	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)
Fear	0.03 (0.01)	0.01 (0.01)	0.03 (0.01)	0.01 (0.01)	0.03 (0.01)	0.04 (0.01)
Happiness	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sadness	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)
Surprise	0.94 (0.02) ***	0.96 (0.01) ***	0.93 (0.02) ***	0.95 (0.01) ***	0.95 (0.02) ***	0.92 (0.02) ***
Neutral	0.01 (0.01)	---	0.01 (0.01)	0.01 (0.01)	---	0.01 (0.01)

$^{\dagger} p < .10$, $^{*} p < .05$, $^{**} p < .01$, $^{***} p < .001$

Appendix C – Monitor Frame Rate Check

Similar to Shi (2017), a Sony DSC-RX10IV Cyber-Shot camera was used assess the frame rate accuracy of the ASUS ROG Swift PG258Q monitor at 200 Hz. Images were captured at 1000 fps with an inverting checkerboard (Figure C1) and the JACBART paradigm administered in studies 2 and 3 (Figure C2) as stimuli. Resulting images suggest the monitor applied a top-to-bottom process when changing frames. In addition, this approach confirmed that targets are indeed presented for 5 ms (i.e., 5 camera images) when it is intended to be presented for 1 frame at 200 Hz.

Figure C1

Images Taken at 1000 fps with an Inverting Checkerboard to Demonstrate the Top-to-Bottom Transition from One Frame to Another on the 200 Hz Monitor used in Studies 2 and 3.

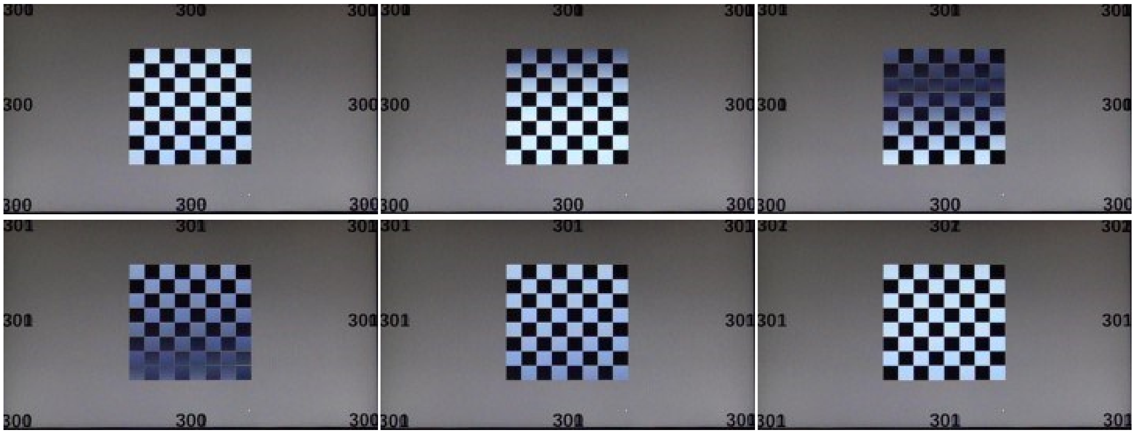

Figure C2

Images Taken at 1000 fps with the JACBART Paradigm to Demonstrate the Transition from a Forward-Mask Frame (red) to a Target Expression Frame (green) to a Backward-Mask Frame (blue) on the 200 Hz Monitor used in Studies 2 and 3.