Modulation of Facial Expression Perception by Body Context

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The present study tested the emotion seed hypothesis, previously not fully tested, which states that facial expression perception is modulated by context based on perceptual similarities shared between facial expressions. The more visually similar a facial expression (e.g. fearful) is to another (e.g. surprised), the more likely they will be confused for one another especially in one another's emotionally congruent context. Therefore only specific emotional contexts will enhance the confusability of a facial expression. Faces expressing the six basic emotions and neutral expressions were mixed and combined with the bodily expressions of these emotions, in a face expression categorization task. Results demonstrate that facial expression perception is influenced by which bodily expression it is combined with. Only a few of the predictions of the emotion seed hypothesis were confirmed. Unpredicted modulations of facial expression perception occurred, such as facial expressions being confused as context incongruent expressions. Given these findings, it is proposed that facial expression perception is influenced by both categorical and underlying dimensional attributes (i.e. intensity and valence).

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Introduction

1.1 Background

Facial expressions are a salient part of human social interaction used to express one's feelings or intentions. Research on the communicative value of facial expressions generally presents highly posed facial expressions in isolation, devoid of any context (Barrett et al., 2007; de Gelder, 2009; Carroll & Russell, 1996). However in ecological settings facial expressions are encountered in a wide diversity of contexts and are never perceived in isolation (Barrett et al., 2007; Barrett et al., 2011). Numerous studies have demonstrated that human facial expression perception, whether measured by categorization or dimensionality (e.g. valence and intensity), is modulated by nearly any type of context (e.g. scene, body, voice, other faces, vignettes, etc.) that the face is paired with as compared to when it is presented in isolation (Barrett et al., 2007; Barrett et al., 2011; Aviezer et al., 2012a; Aviezer et al., 2012b; Aviezer et al., 2012c; Aviezer et al., 2008; Carroll & Russell, 1996; Wieser & Brosch, 2012; Van den Stock et al., 2007; Russell & Fehr, 1987; Righart & de Gelder, 2008).

These numerous demonstrations that the categorization of basic emotions can change as a result of context are in direct conflict with the most prominent theory of facial expression perception (Barrett et al., 2007), namely the basic emotion theory. The theory claims that there are 6 evolved facial expressions (angry, disgusted, fearful, happy, neutral, sad, and surprised) that are universally expressed and recognized in a consistent and context invariant manner (Ekman & O'Sullivan, 1988; Ekman, 1992). Despite the recent evidence that the perception of basic emotions is context variant, a fully validated explanation for how context could modulate the perceived category of a facial expression is lacking in the literature. In the remainder of this thesis, context is operationalized as background information (e.g. scene, body, vignette, tone of voice, etc.) intentionally presented to participants that is task irrelevant (e.g. facial expressions are presented with a scene and participants are asked to categorize the emotion of the facial expression).

A number of hypotheses with varying levels of experimental support attempt to explain how context modulates the perceived category of facial expressions (Barrett et al., 2007; Aviezer et al., 2008; Russell, 1997). One hypothesis that has amassed good experimental support, yet remains to be fully validated, is the *emotion seed hypothesis* (Aviezer et al., 2008; Aviezer et al., 2011; Aviezer et al., 2012a; Aviezer et al., 2012c; Perry et al., 2013; Mondloch et al., 2012; Mondloch et al., 2013a). The emotion seed hypothesis states that categorizing one facial expression (e.g. anger) as another (e.g. disgusted) is due to the perceptual similarity between the two facial expressions. The hypothesis predicts that the more perceptually similar a target facial expression (e.g. fearful) is to a context's (e.g. sad bodily expression) emotionally congruent facial expression (sad), the more the target facial expression (fearful) will be categorized as the context's emotionally congruent facial expression (sad) (Aviezer et al., 2008).

The aim of this thesis is to test the generalizability of the emotion seed hypothesis by testing the degree to which body-only context stimuli of all 6 basic emotions (angry, disgusted, fearful, happy, sad, and surprised) and neutral expression affect the categorization of these emotions expressed by the face. Three of these facial expressions (neutral, happy, and surprised) and many of the pairings were previously untested (e.g. fearful facial expression on surprised bodily expression, neutral facial expression on an angry bodily expression, etc.). It is important to exhaustively test the basic emotions as the emotion seed hypothesis may not generalize to all basic emotions, in which case it would be an incomplete explanation for how context could modulate the perceived category of facial expressions. The main goal of this thesis was to undertake such an exhaustive test.

1.2 Facial Expressions in Context

Despite differences in methodology and a diversity of studied contexts, there are a number of consistent findings among studies of facial expression perception in context. i) Facial expression categorization is robustly affected by context even with increasing difficulty in a second task (e.g. scene; Righart & de Gelder, 2008, e.g. body; Aviezer et al., 2011); ii). effects of context occur regardless of instructions (i.e. participants are told to ignore the context; e.g. voice; de Gelder & Vroomen, 2000, e.g. body; Aviezer et al., 2011, e.g. scene; Righart & de Gelder, 2008); iii) contexts are rapidly processed as suggested by electrophysiology (e.g. scene; Bar, 2004, e.g. body; Meeren et al., 2005, e.g. voice; de Gelder et al., 1999); and iv) context can affect the emotional recognition of the facial expression (e.g. scene; Righart & de Gelder, 2006, e.g. body; Aviezer et al., 2008, e.g. voice; de Gelder & Vroomen, 2000, e.g. vignettes; Carroll & Russell, 1996). Facial expressions paired with all types of context exhibit congruency effects such that participants respond faster and are more accurate in categorizing the facial expression when it is paired with a congruent context (i.e. the facial expression and context denote the same emotion), and are slower to respond and less accurate when it is paired with an incongruent context (i.e. the facial expression and context exemplify different emotions) (e.g. Righart & de Gelder, 2008; Meeren et al., 2005; de Gelder & Vroomen, 2000). Other findings demonstrate the bi-directionality of contextual effects such that when the task is to categorize what a bodily expression or voice is expressing, the categorization can be influenced by the facial expression that it is paired with (e.g. voice; de Gelder & Vroomen, 2000, e.g. body; de Gelder, 2009). Indeed there is bi-directionality in terms of how scene, bodily expression and affective prosody influence the perception of one another (e.g. de Gelder, 2009; Van den Stock et al., 2007; Stienen et al., 2011).

Context affects how facial expressions are perceived automatically (i.e. regardless of instructions), rapidly, without selective attention (i.e. dual tasks) and robustly (i.e. multiple types of context effect facial expression perception). How facial expressions are perceived in context can no longer be ignored in facial expression perception theory. Some authors have even suggested that the multi-directional nature of cross modal integration and modulation of affective signals should lead to a broader theory of emotion signal processing (de Gelder & Vroomen, 2000).

1.3 Facial Expressions Paired with Bodily Context

Bodily expressions affect the perceived valence (e.g. Aviezer et al., 2008), intensity (e.g. Aviezer et al., 2011), and category of some facial expressions (e.g. Aviezer et al., 2008). In one study two facial expressions were perceived almost unanimously as a categorically different expression dependent on what bodily context it was paired with (Avizer et al., 2008). When a disgusted facial expression was paired with an angry bodily expression the facial expression was categorized predominantly as an angry facial expression (shift in categorization). However, when it was paired with a disgusted (congruent) context, the facial expression was predominantly accurately categorized as disgusted (Aviezer et al., 2008). A shift in categorization was also found for sad faces in a fearful bodily context such that sad faces were predominately categorized as fearful (sad faces are most perceptually similar to fearful faces; Aviezer et al., 2008). Furthermore, when disgusted facial expressions were paired with sad and fearful bodily expressions they were still predominantly recognized as disgusted although magnitude of categorization errors varied depending on how similar the disgusted facial expression was to sad (moderately similar) and fearful (low similarity) facial expressions (Aviezer et al., 2008). Other studies by the same group report strong context effects without complete categorical shifts (e.g. ~30% drop in accuracy for angry, disgusted, fearful and sad facial expressions paired with contexts where they were highly perceptually similar to the context congruent facial expression; Aviezer et al., 2011; Aviezer et al., 2012c; Aviezer et al., 2012a).

Two studies from a different group also support the emotion seed hypothesis but report a more modest average decrease in accuracy (e.g. 11%) when the facial expression of fear was paired with a sad body and vice versa (Mondloch, 2012; Mondloch et al., 2013a). In contrast, a third study from that same group which mixed and matched facial and bodily expressions of anger, sadness, and fear demonstrated results counter to the emotion seed hypothesis (Mondloch et al., 2013b). The study reported that sad facial expressions were more perceptually similar to angry and fearful facial expressions than angry and fearful facial expressions were to each other. However angry bodily expressions decreased accuracy of fearful facial expressions more than sad bodily expressions and sad postures had more of a negative impact on the accurate recognition of fearful facial expressions than angry facial expressions. This is so far the only study to demonstrate effects incongruent with the emotion seed hypothesis. If other currently untested facial and bodily expression combinations may have similar emotion seed incongruent effects remains to be tested.

1.4 Bodily Expressions of Emotion

Bodily expression perception is a burgeoning field quite unlike the facial expression perception literature as it lacks widely used bodily expression databases and those that exist (Schindler et al., 2008; Thoma et al., 2013; Mondloch, 2012; Atkinson et al., 2004; de Gelder & Van den Stock, 2011) have considerable limitations (e.g. lack of full validation, limited categorization options, and the use of paraphernalia in addition to the body). Despite the limited amount of work done with bodily expressions, evidence shows that bodily expression processing, like facial expression processing, is reliable (i.e. bodily expressions are recognizable), rapid, automatic (i.e. processed regardless of instructions), and unaffected by additional task demands (i.e. retaining a list of numbers; de Gelder, 2009; van de Riet et al., 2009). Bodily expressions can be seen from far away and are useful for identifying one's intentions as well as allowing for the observer to plan his actions (de Gelder, 2009). This contrasts with facial expression processing where facial expressions must be viewed up close, making them more fine grained and therefore useful for directly communicating a felt emotion (de Gelder, 2009; van de Riet et al., 2009). This distinction between facial and bodily expressions is highlighted by the findings that fearful facial expressions are generally the most poorly recognized facial expressions of the 6 basic emotions whereas bodily expressions of fear are one of the best recognized bodily expressions (de Gelder et al., 2004; Kret et al., 2011; Hajikhani et al., 2003, de Gelder, 2009). These findings suggest that fear recognition might rely more on the body than on the face which makes sense from an evolutionary perspective as it is probably best to be able to recognize fear from a distance as opposed to a close up encounter. However overall there has been very little work validating bodily expressions and this gap in our knowledge must be addressed. Another goal of this thesis was to fully validate an existing database of bodily expressions without paraphernalia (from Schindler et al., 2008) by a large sample of individuals using a large number of categorization options.

1.5 Description of my Studies and Predictions

The present study tested the emotion seed hypothesis in a fully balanced design that presented facial expressions of the six basic emotions and neutral expressions, mixed and matched on emotional bodily expressions of the same emotions (7 facial expressions by 7 bodily expressions). It should be noted that previously discussed studies that tested the emotion seed hypothesis vary between a 2 by 2 and 4 by 4 design (e.g. Mondloch et al., 2012; Aviezer et al., 2012c). None of the previous studies examined happy, neutral, or surprised facial expressions on bodily expressions and so whether the emotion seed hypothesis is generalizable to all basic emotions remains to be tested. Isolated facial and bodily expressions were also presented, along with the face-body composite stimuli. Participants were tasked with categorizing the emotion expressed by the face except when isolated bodily expressions were presented (in this case they categorized the bodily expression). Participants categorized the expressions using a 7 option forced choice methodology where the responses were the 6 basic emotions and neutral expression. A response was accurate when a participant categorized the expression as the intended expression. An error (mis-categorization) occurred when a participant responded with any of the other 6 categorization terms other than the accurate response.

Isolated facial expressions served as a baseline to compare to how facial expressions were perceived in different contexts. Accurate and inaccurate categorizations of isolated facial expressions were analyzed to be later compared to how context affected accurate and inaccurate categorizations of the same facial expressions. For example, how categorizations of isolated sad facial expressions compared to categorizations of sad faces presented with a fearful body. Using accuracy data from the validation study (Tottenham et al., 2009), it was predicted that happy, then angry, and then neutral facial expressions would be the most accurately recognized whereas surprised, then sad, then disgusted, and then fearful expressions would be the least accurately recognized in decreasing order of accuracy (Table 1).

Predictions for what the isolated facial expressions would be most perceptually similar to were originally derived from the perceptual similarity model used to test the emotion seed hypothesis (Aviezer et al., 2008). The model was developed in a study where facial expression categorization data from a computer program and human participants were compared to one another via separate multi-dimensional scaling (MDS) plots (see Susskind et al., 2007 for more details). MDS plots are used to visualize how similar or dissimilar various data points are to one another based on the distance between the data points. The MDS plots of human participants were used to determine perceptual similarity between facial expressions such that the closer two emotions (e.g. fearful and surprised) were on the plot, the more perceptually similar they were to one another (Aviezer et al., 2008). The data used to build the MDS plots in Susskind and colleagues (2007) represent perceptual similarities based on different facial expression databases (i.e. Ekman & Friesen, 1976 (POFA database); Biehl et al., 1997 (JACFEE and JACNeuF databases)) than the one used in this study (i.e. Tottenham et al., 2009 (NIMSTIM)). Given inherent differences between facial expression databases (Gronenschild et al., 2009) predictions for what isolated facial expressions would be perceptually similar to were therefore based on confusion data from the NISTIM validation study (Tottenham et al., 2009). The confusion data were entered into an MDS analysis (Figure 1).

Predictions from the Susskind and Tottenham models are shown in Table 1. Predictions are given in presumed order of decreasing facial expression similarity. The order given should be understood such that the first expression given is highly perceptually similar to the target facial expression, the second is moderately similar, and the last shares very little perceptual similarity. It was predicted that angry facial expressions would be most perceptually similar to disgusted, then sad and then neutral expressions; disgusted facial expressions to angry, then sad, and then fearful expressions; fearful facial expressions to surprised, then sad, and then disgusted expressions; happy facial expressions to neutral, then fearful, and then surprised; neutral facial expressions to happy, then angry, and then sad; sad facial expressions to disgusted, then fearful, and then angry expressions; and surprised facial expressions with fearful, then sad and then happy facial expressions.

The MDS plot that follows and the other presented were created in IBM SPSS 21 using the Proxscal scaling algorithm for multidimensional scaling. Both MDS plots were created from a single full matrix of averaged confusion data across all participants from the respective experiments. Figure 1 is an MDS plot of a single full matrix of averaged confusion data across all participants from Tottenham and colleagues (2009). Both plots are plotted on two dimensions, however in this study the dimensions are not of interest and are not interpreted. What is of interest is the distance between the data points as this represents the perceived similarity between facial expressions. The distances were generated iteratively by the Proxcal algorithm to find the best fit for the data, and are only meaningful in that the distance measures can be compared to one another. In other words, the distance measures reported are largely arbitrary and only have meaning in the context of the overall plot (e.g. one data point (e.g. fearful) is closer to a second data point (surprised) than it is to a third (happy)) (Hout et al., 2013). Facial expression similarity is determined in this way in order to be in line with how the emotion seed hypothesis was tested in Aviezer and others 2008.

Distances

	Angry	Disgusted	Fearful	Happy	Neutral	Sad	Surprised
Angry	.000						
Disgusted	.590	.000					
Fearful	1.216	.977	.000				
Happy	1.281	1.479	.957	.000			
Neutral	.744	1.169	1.182	.677	.000		
Sad	.624	.455	.606	1.040	.866	.000	
Surprised	1.331	1.098	.123	.960	1.252	.726	.000

Figure 1
An MDS plot of the NIMSTIM confusion matrix found in Tottenham et al., 2009 and the distances between facial expressions.

<u>Facial Expression Order of Accuracy Prediction:</u> Happy>Angry>Neutral>Surprised>Sad>Disgusted>Fearful		
<u>Facial Expression</u>	**<u>Tottenham et al., 2009 (Predictions)</u>**	**<u>Susskind et al., 2007</u>**
Angry	Disgusted > Sad > Neutral	Disgusted> Sad> Fearful
Disgusted	Sad > Angry > Fearful	Angry> Sad> Fearful
Fearful	Surprised > Sad > Happy	Surprised> Sad> Disgusted
Happy	Neutral > Fearful > Surprised	Surprised> Fearful> Disgusted
Neutral	Happy > Angry > Sad	-
Sad	Disgusted > Fearful > Angry	Fearful> Disgusted> Angry
Surprised	Fearful > Sad > Happy	Fearful> Happy> Disgusted

Table 1
Predictions for order of facial expression accuracy and facial expression similarity (based on Tottenham et al., 2009). Facial expression similarity predictions are compared to the Susskind model (based on Susskind et al., 2007).

Isolated bodily expressions were included in the present study as the bodily expression database used in the present study had not previously been fully validated (Schindler et al., 2008). In Shindler et al., 2008, each face-body composite was categorized by only one participant and the facial expression was visible (i.e. categorization was not done for body-only stimuli) (Schindler et al., 2008). The other handful of studies where body-only stimuli are validated present with a variety of limitations which include a small number of categorization options (i.e. 2; Thoma et al., 2013; i.e. 3 Mondloch, 2012), less than 67% average accuracy for each of the five bodily expressions (Atkinson et al., 2004), or only four bodily expressions tested (de Gelder & Van den Stock, 2011; Mondloch, 2012). As a result a secondary goal of the present study was to fully validate the body-only database from the Schindler et al. 2008 study (i.e. each stimulus categorized multiple times, bodily expressions for all basic emotions and neutral, and 7 categorization options). An exploratory goal of this study was to validate how bodily expressions were confused for one another.

From the bodily expression validation study (Schindler et al., 2008) it was predicted that happy bodily expressions, followed by neutral and then fearful bodily expressions would be the best recognized whereas sad, surprised, then angry, and then disgusted expressions would be the worst recognized bodily expressions in order of descending accuracy. Important to note as well is how bodily expressions may be confused for one another. For instance if a bodily expression is not well recognized or recognized as another emotion then that is likely to affect how a facial expression will be confused or not within that bodily context. Due to the dearth of information for how bodily expressions would be confused for one another this part of the study was exploratory. Therefore there were no predictions for how one bodily expression may be confused for one another or how the confusion of a bodily expression may affect the perception of paired facial expressions.

It was predicted that when facial expressions and bodily expressions were congruently paired, that facial expressions would be significantly more accurately recognized than when presented in isolation (assuming that the isolated bodily expressions were recognized mostly as the intended expression) (e.g. Meeren et al., 2005).

Following the emotion seed hypothesis, it was predicted that when a target facial expression (e.g. fearful) was paired with a bodily expression emotionally congruent with what the isolated target facial expression was perceptually similar to (e.g. surprised), the target facial expression (fearful) would be more categorized as the perceptually similar expression (surprised) than it was in isolation (again, assuming that the isolated bodily expressions were recognized mostly as the intended expression). This was predicted to occur for all three levels of perceptual similarity for each facial expression (i.e. the most similar, moderately similar, and the least similar facial expression). The largest confusion should occur in the context where the target facial expression shares the most perceptual similarity to the context congruent facial expression (e.g. angry facial expression categorized as disgusted in disgusted context) followed in decreasing order by the confusion in the context that is congruent to the moderately similar facial expression and the confusion in the context that is congruent to the least similar facial expression. Finally, accuracy for the target facial expression in the predicted contexts should decrease in a similar stepwise fashion and accuracy should not significantly differ for unpredicted contexts.

Here are a summary of the predictions and an explanation as to why they are measured, broken up by major category: 1.There are specific predictions for how isolated facial expressions will be accurately and inaccurately categorized (to compare to accurate and inaccurate categorization when paired with various bodily expressions). 2. There are specific predictions for how isolated bodily expressions will be accurately categorized (to validate the bodily expression database). 3. Facial expressions will be significantly more accurately categorized when paired with a congruent bodily expression than when presented in isolation. 4. Context will have more of an effect on accurate and inaccurate categorization of a facial expression depending on how similar the target facial expression is to the context congruent facial expression (main prediction and specific aim of this thesis).

Methods

2.1 Participants

Two hundred and thirty one (231), 17-26 year old undergraduate students all with normal or corrected-to-normal visual acuity were recruited from the University of Waterloo to participate in an online study for course credit (study 1 (n=143), study 2 (n=88)). Participants were pre-screened and could participate only if they were born and raised in North America (due to cultural differences in emotion recognition; e.g. Blais et al., 2008), were fluent English speakers, were not currently taking any psychiatric drugs, had no history of drug abuse or head trauma, and didn't have any neuropsychological disorders. A total of 107 participants (study 1 (n=54), study 2 (n=53) were removed for various reasons (see Table 2 for details). A final sample of 124 participants (study 1 (n=89), study 2 (n= 35)), 17-26 year old, Mean= 20.8, 81 females) remained for data analysis. Losing so many participants may seem high but this was done intentionally to ensure that only the best possible data were used. For example, more than two thirds of the excluded participants were excluded as they did not meet the strict exclusion criteria of completing at least 96% of the experiment, which was to ensure meaningfulness of the data given the small number of trials per condition.

	Part 1	**Part 2**	**Total Removed**
One Block Presented Twice	0	19	19
Did not complete at least 96% of the experiment (~ half a block lost)	41	29	70
Took over 3 hours to complete a 2 hour study	8	4	12
Accuracy in a single block was below chance	4	0	4
Outside age range (17-26)	1	1	2
Total Removed	54	53	107

Table 2
Outlines the number of participants that were removed from data analysis and the specific reason for doing so.

2.2 Stimuli

Static photographs of 8 individuals (4 men, 4 women), each with angry, disgusted, fearful, happy, neutral, sad, and surprised expressions (for a total of 56 stimuli) were selected from the NimStim set of facial expressions (see Tottenham et al., 2009 for a full description and validation of the stimuli)[1]. As well, static photographs of 8 different bodies (4 men, 4 women), each with angry, disgusted, fearful, happy, neutral, sad, and surprised expressions (for a total of 56 stimuli) were selected from a database of bodily expressions created by Schindler and colleagues (see Schindler et al., 2008 for a full description of the stimuli). Hair remained on the final facial expression stimuli in order to maintain ecological validity (see Figure 2a) however care was taken to ensure that all images excluded piercings or any other easily identifiable and distinguishable external features.

Individual stimuli were combined in GIMP 2 to create realistic looking congruent and incongruent facial and bodily expression composites. The composites, like the individual stimuli, were converted to greyscale, presented against a white background, and were 500 (width) x 752 (height) pixels in size. One actor's set of facial expressions was paired with another actor's set of bodily emotional expressions to create 8 (4 male, 4 female) artificial models. Each composite individual (head attached to a body) expressed 49 different composite emotions (7 facial expressions x 7 bodily expressions; e.g. angry face on disgusted body). In total participants viewed 504 experimental stimuli: 56 isolated facial expressions (Fig. 2a), 56 isolated bodily expressions (Fig. 2b) and 392 composite stimuli (Fig. 2c), (8 trials per condition).

[1] Development of the MacBrain Face Stimulus Set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set.

a. Isolated Facial Expressions.

b. Isolated Bodily Expressions

c. Congruently Paired Facial and Bodily Expressions

Figure 2
Examples of a) the facial expression, b) the bodily expression, and c) the congruently paired facial and bodily expression stimuli used; all images were shown in greyscale. From left to right: Angry, Disgusted, Fearful, Happy, Neutral, Sad, and Surprised. Note that each of the eight identities expressed all emotions in the actual experiment.

2.3 Experimental Setting

Participants performed the experiment in a location and on a computer with an internet connection of their choosing through the online survey application Qualtrics ™. Participants were asked to carefully consider participation in the study and to only participate if they were focusing solely on the study, no distractions were present (e.g. other people, music, tv, etc.), if their computer monitor was at least 15 inches, and if they could see an example stimulus while in full screen mode.

2.4 Materials and Procedure

After login to the online experiment and upon consent, participants completed a demographic questionnaire assessing self-reported bodily expression recognition, size of computer monitor, current mood and intensity of that mood, feelings of anxiety when interacting with others, and a catch question which required the participants to respond in a unique way in order to prove that they actually read the instructions. Current mood and social anxiety were probed as these constructs have been shown to interact with how people perceive emotional expressions (e.g. Schmid & Mast, 2010; Hunter et al., 2009).

Participants were introduced to the structure of the experiment through a practice session which had two examples of all stimuli types (face only, body only, and face-body composite). The stimuli presented in the practice session were never presented in the actual experiment. A participant could run through the practice session up to three times. A trial started with a stimulus which was presented in the center of the screen for one second. Immediately after the stimulus was presented a response screen appeared which had the following question "What emotion was the face expressing?" This question occurred in 8 out of 9 blocks; in the body-only block the question that appeared after each stimulus was "What emotion is the body expressing?". The participants could respond to the question by choosing one of seven vertically presented options with a mouse click. The options were: Anger, Disgust, Fear, Happiness, Neutral, Sadness, and Surprise. For a given participant, the order of the responses was kept constant for all trials. However, seven pre-set orders of responses were created, which were randomly presented across participants. A pre-set order of responses was presented to at least 31 participants and to 41 participants at most. After the participant made a response she could advance to the next trial by clicking an arrow button on the side of the screen or wait until it automatically advanced to the next trial (after 4 seconds). Participants were instructed to respond as quickly and accurately as possible. If they did not know how to respond they were encouraged to give their best guess. A new trial began with the presentation of a new stimulus (see Figure 3 for an example of a typical trial).

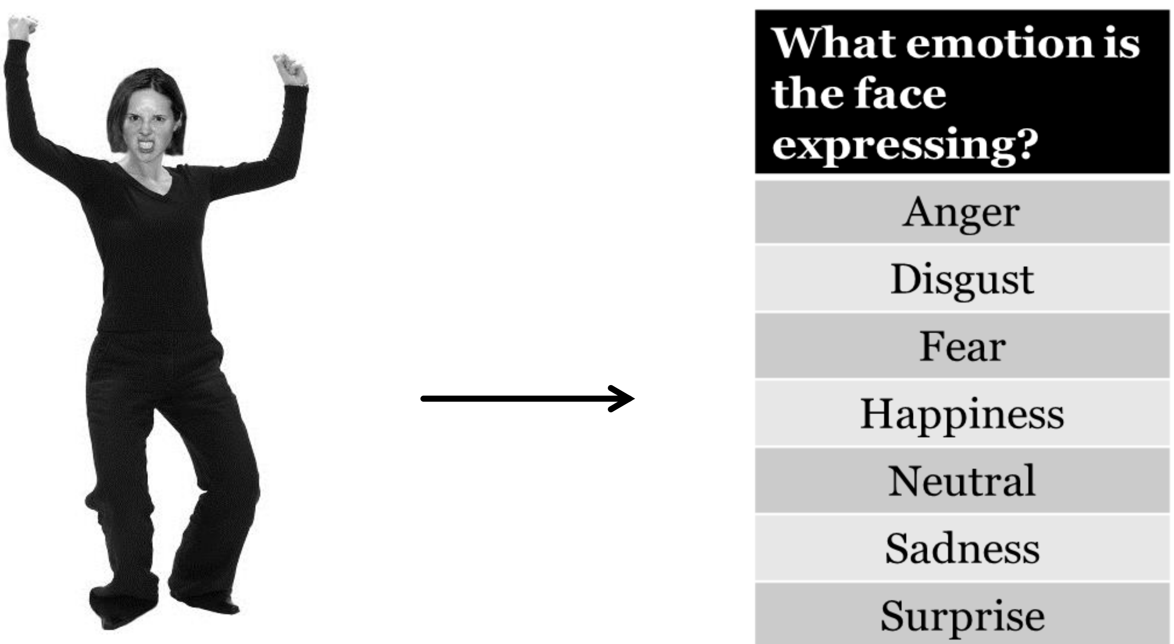


Figure 3
Example trial with face-body composite. Subjects were tested on 512 trials as follows. First the test image appeared for one second, immediately after the presentation of the stimulus a response screen appeared with the question “What emotion was the face expressing?” (in the isolated body expression block the question was: “What is the body expressing?”) and participants had seven options from which to choose (Anger, Disgust, Fear, Happiness, Neutral, Sadness, and Surprise). Participants were instructed to choose the word they thought best represented the facial expression that they just saw. Subjects had 4 seconds to respond before the study advanced to the next trial.

Testing was carried out in nine randomly presented blocks each with a fixed set of 56 stimuli that were randomly presented within the block. Therefore each participant viewed a unique order of the stimuli. Of the nine blocks one had 56 face-only stimuli, one had 56 body-only stimuli and the other seven blocks each contained 56 face-body composite stimuli. The other 7 face-body composite blocks were composed of the 56 congruent stimuli (face and body expressing the same emotion) and the 336 incongruent stimuli (face and body expressing different emotions). Included in each of the face-body composite blocks and randomly presented along with the other stimuli was a catch stimulus (i.e. a man performing an emotionally neutral task with his face blurred out) (Fig. 4). When a participant saw a catch trial they were instructed to respond “Anger”. “Anger” was not chosen for any particular reason, other than to be a non-obvious or unique response to the catch stimulus (e.g. neutral). Catch trials were included to ensure that participants were attentively responding and not intentionally rushing through the experiment (the total time it took to complete this online study was also monitored). All participants included in the data analysis caught over half of the catch trials (including the question in the demographic questionnaire). Between each block there was an instruction screen which informed the participant of the type of upcoming trials (e.g. face-only expressions), what question one should be answering, and the order of the responses. The instruction screen also described that there could be a catch trial in the block, how to respond to it, and that one could take a break at this time. In total there were 63 conditions (7 face only emotions, 7 body only emotions, 7 congruent face-body expressions, and 42 -7 facial expressions x 6 bodily expressions – incongruent face-body expressions), with 8 trials per condition (8 models).

Figure 4
Example of a catch trial used in the face-body composite blocks.

After the experiment participants were asked to leave comments if they encountered any problems (e.g. slowed internet connection). Then they completed the Center for Epidemiologic Studies Depression scale (CES-D), a self-report measure of cognitive and somatic symptoms of depression over the past week (Radloff, 1977), as there is extensive evidence that depression impacts how people perceive emotional expressions (e.g. Bourke et al., 2010). The CES-D is a 20 item scale with a Likert response format and participants respond to how frequently (e.g. 0 = rarely, 4 = almost all the time) they have experienced specific depressive symptoms (e.g. “My appetite was poor.”). Higher scores (range: 0-60) indicate greater levels of depressive symptoms. Scores up to 16 are not clinically significant whereas higher scores and certain depressive symptoms make up varying degrees of possible depressive episodes. Measured CES-D scores ranged from 0-45 (mean= 15.76). Sixty-nine participants had a score under 16 and 55 participants had a score of 16 or higher. As such it did not make sense to exclude participants based on their CES-D score as almost half the remaining sample had a score of 16 or higher.

In study 1, face-body composite stimuli were randomly placed into one of seven face-body composite blocks. Therefore conditions were not counterbalanced across blocks and each block had a unique mixture of the 49 conditions. In study 2 a balanced and slightly different design was used to address any possible context effects that could have occurred in study 1. In this second iteration of the study, the 392 composite face-body stimuli (56 congruent + 332 incongruent) were split into 8 blocks of 49 stimuli each, instead of the seven blocks of 56 stimuli as in study 1. The blocks with the isolated facial and bodily expressions remained the same as in study 1 except that they also included catch stimuli (in the body-only block a different catch stimulus was used, see Fig 5). In study 2 one of the composite blocks was repeated twice by mistake for 19 participants before the mistake was caught and fixed (those participants were removed from the final analyses as mentioned previously in Table 2). As seen in the Appendix, the data collected for these two studies were remarkably similar. Therefore, the final participants from studies 1 and 2 were mixed together for the final statistical analysis (N=124).

Figure 5
Example of a catch trial used in the body-only blocks of study 2.

2.5 Data Analysis

Accuracy for each condition per participant was calculated as hits over the number of trials for that condition (8) (i.e. each participant had an average score for each condition). A hit was defined as categorization as the intended expression (i.e. correct categorization). Blank responses were counted as misses for each expression. Mis-categorizations were calculated as the number of times a participant incorrectly categorized the expression as one of the other 6 expressions (e.g. disgusted categorized as angry) over the number of trials for that condition (8). If a mis-categorization as a particular expression occurred 5% of the time or more and occurred significantly more than at least one other mis-categorization, then the target expression was said to be confused as this miscategorised expression. Data from the face- and body-only blocks were analyzed for the face- and body-only data analyses respectively. For the rest of the analyses the data from the remaining blocks were combined by facial expression and comparisons were made across all conditions except the body-only condition.

Data were analyzed using repeated measures analyses of variance (ANOVA). The Greenhouse-Geisser correction for the degrees of freedom and mean squares were used when sphericity was violated (i.e. when the Mauchly's test of sphericity was significant), generalized eta squared ($\eta^2 G$) was calculated for effect sizes, and all multiple comparisons were Bonferroni corrected. Generalized eta squared is preferable to partial eta squared as it allows for easier comparison across study designs (e.g. between subject designs versus within subject designs; Bakeman, 2005).

First the correct categorization of isolated faces was compared across emotions to see which facial expressions were best recognized. Then categorization errors (i.e. mis-categorizations) for isolated faces were compared within an expression to verify what a facial expression was confused as. Similarly, correct categorization of isolated bodily expressions was compared across emotions to determine which bodily expressions were best recognized. Categorization errors for isolated bodily expressions were also compared within an expression to determine what bodily expressions were confused as. An analysis of correct categorization across all 8 conditions where a facial expression was presented determined in what conditions a facial expression was best or worse recognized. Pairwise t-tests helped to confirm whether there was a congruency effect and in what conditions accuracy was affected the most for a certain facial expression. Predicted effects were analyzed within a condition and across conditions to verify whether a predicted effect occurred the most in the predicted condition.

Results

3.1 Isolated Facial Expression

3.1a Analysis of Accurate Categorizations for Isolated Facial Expressions

Average accurate categorizations for isolated facial expressions were compared across expressions to determine which facial expressions were best and worst recognized; and to compare with the literature on facial expressions to ensure that the stimuli elicited classically reported recognition patterns. A one-way repeated measures ANOVA with facial expressions as the independent variable (7 levels) and correct categorization as the dependent variable confirmed a significant main effect of facial expression, F (4.16, 512.25) = 175.6, MSE = .033, $p < .0001$, $\eta^2 G$ =.51. As can be seen on Fig.6, accuracy decreased in the following order: happy > surprised ≥ neutral ≥ sad > angry ≥ disgusted > fearful. Pairwise comparisons confirmed that happy expressions were significantly more accurately categorized (97.58%) than all other facial expressions, all ps < .0004. Accurate categorization for surprised expressions (91.74%) was significantly larger than all other expressions except happy and neutral (89.82%; p=1), all significant ps<.004. Sad (85.99%) and neutral facial expressions were significantly more accurately categorized than angry (81.14%), disgusted (75.5%), and fearful (43.25%) facial expressions (ps<.05) and did not differ significantly from each other (p=0.41). Angry and disgusted facial expressions were significantly more accurately categorized than fearful expressions (ps<.0001) and did not significantly differ from each other (p=0.25). Fearful facial expressions were significantly less accurately categorized than all other facial expressions, all ps < .0001 (*Fig. 6*). For the most part and according to predictions, facial expression accurate recognition reproduced classically reported effects such as happy facial expressions being the best recognized and fearful and disgusted facial expressions being two of the worst recognized facial expressions (e.g. Tottenham et al., 2009).

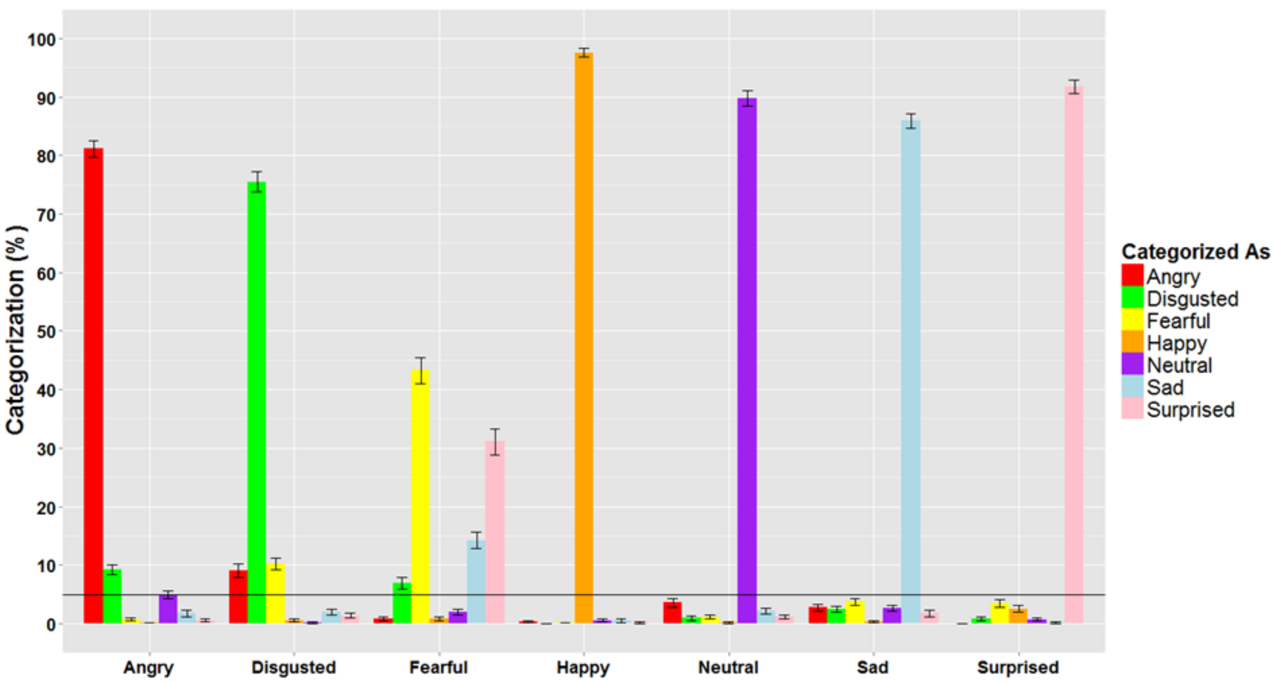
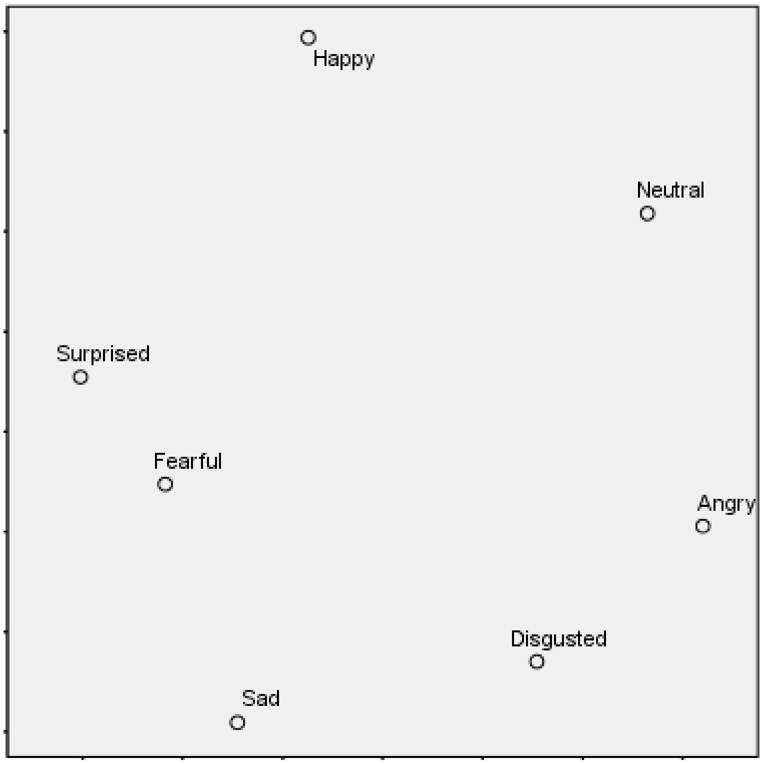


Figure 6
Overall breakdown of how isolated facial expressions were categorized. The horizontal black line is meant to help distinguish categorizations above or below 5%.

3.1b Analysis of Mis-categorizations for Isolated Facial Expressions

A single full matrix of averaged confusion data from the isolated face condition was run through the Proxscal scaling algorithm in IBM SPSS 21 to create an MDS plot. Predictions for how facial expressions will be confused as one another in different contexts were based on the following visualization (Figure 7).



Distances

	Angry	Disgusted	Fearful	Happy	Neutral	Sad	Surprised
Angry	.000						
Disgusted	.428	.000					
Fearful	1.078	.823	.000				
Happy	1.255	1.328	.938	.000			
Neutral	.635	.922	1.105	.763	.000		
Sad	1.010	.611	.498	1.377	1.307	.000	
Surprised	1.280	1.075	.273	.818	1.179	.759	.000

Figure 7
The MDS plot of the current study's confusion matrix and the distances between facial expressions.

Angry facial expressions were closest to disgusted (.428), then neutral (.635), and then sad (1.01) facial expressions. Disgusted facial expressions were closest to angry (.428), then sad (.611), and then fearful (.823) facial expressions. Fearful facial expressions were closest to surprised (.273), then sad (.498) and then disgusted (.823) facial expressions. Happy facial expressions were closest to neutral (.763), then to surprised (.818), and then to fearful (.938) facial expressions. Neutral facial expressions were closest to angry (.635), then to happy (.763), and then to disgusted (.922) facial expressions. Sad facial expressions were closest to fearful (.498), then to disgusted (.611) and then to surprised (.759) facial expressions. Surprised facial expressions were closest to fearful (.273), then sad (.759), and then happy (.818) facial expressions. These data serve as the basis for the predictions for how much facial expressions will be confused for one another in different contexts. The emotions of the facial expressions that are closest and furthest from a target facial expression denote the emotions of the contexts that will have the most and least effect respectively, in terms of accuracy and confusion on the target facial expression.

3.2 Isolated Bodily Expressions

3.2a Analysis of Accurate Categorizations for Isolated Bodily Expressions

Average accurate categorizations for isolated bodily expressions were compared across expressions to determine which bodily expressions were best and worst recognized; and to fully validate a database of isolated bodily expressions. A one way repeated measures ANOVA with accurate categorization as the dependent variable and bodily expressions (seven levels) as the independent variable revealed a significant main effect of bodily expression, $F(4.95, 609.42)= 133.3$, $MSE=.042$, $p<.0001$, $\eta^2G= .45$. As seen on Fig.6, accuracy decreased in the following order: neutral ≥ fearful ≥ happy ≥ angry > sad ≥ surprised ≥ disgusted. Pairwise comparisons confirmed that neutral bodily expressions (84.88%) were significantly more accurately categorized than all other bodily expressions except fearful bodily expressions (80.84%), all $ps<.0003$ (*Fig. 10*). Fearful bodily expressions were significantly more accurately categorized than all other bodily expressions other than neutral and happy bodily expressions (76.01%), all significant $ps<.005$. Happy and angry (72.58%) expressions were not significantly different from each other ($p=1.00$) but were more accurately recognized than disgusted (38.41%), sad (47.88%)

and surprised (43.35%) expressions (*ps*<.0001). Disgusted, sad, and surprised bodily expressions were significantly less accurately categorized compared to all other bodily expressions, *ps*<.0001. Disgusted bodily expressions were significantly less accurately recognized than sad bodily expressions (*p*=.012). The full validation of isolated bodily expressions revealed that the results differed largely from the original validation (Schindler et al., 2008). The original validation reported that the bodily expressions were more accurately recognized than in this study, likely due to the pairing of bodily expressions with their congruent facial expressions in the original validation. This points to the need for more full validations of isolated bodily expressions.

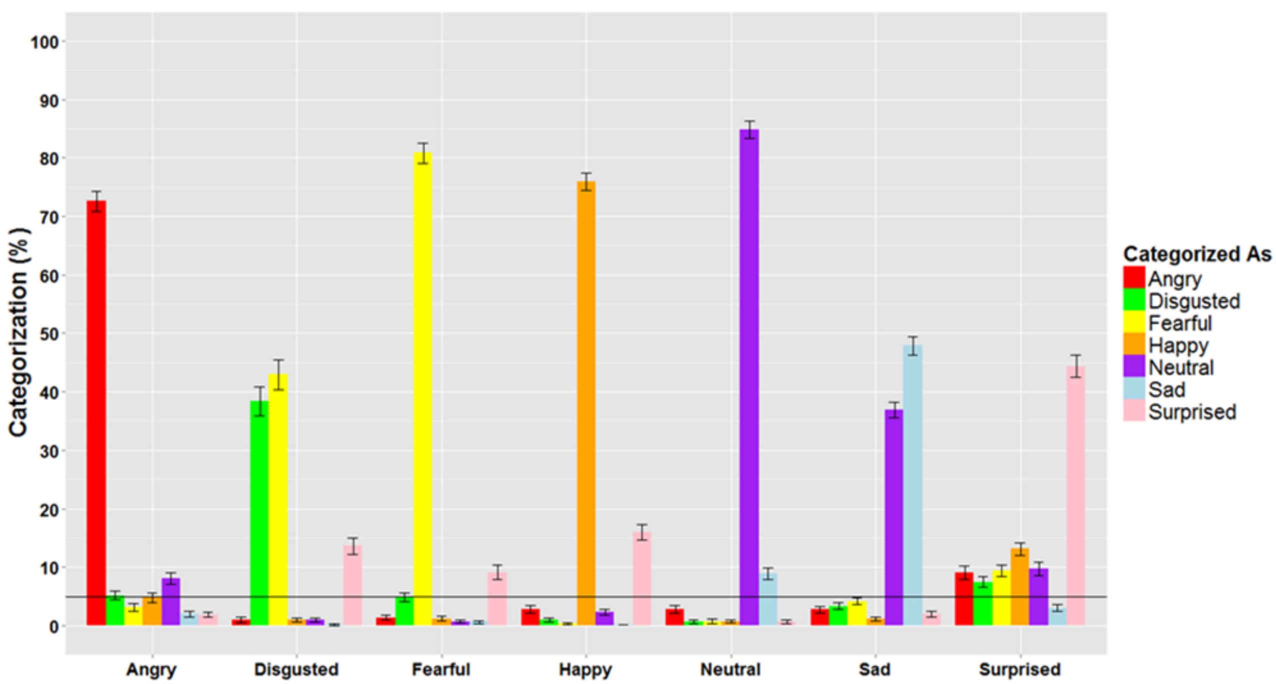


Figure 8
Overall breakdown of how isolated bodily expressions were categorized. The horizontal black line is meant to help distinguish categorizations above or below 5%.

3.2b Analysis of Mis-categorizations for Isolated Bodily Expressions

For each bodily expression (e.g. anger) the average percentage of all incorrect categorizations were compared to determine whether a bodily expression was significantly confused as another expression. A one way repeated measures ANOVA with emotion as the independent variable (6 levels) and percent incorrect categorization as the dependent variable was used for each bodily expression. This type of analysis was preferred to an MDS analysis as bodily expressions are not further analyzed and mis-categorizations of bodily expressions are meant to further interpretations of how context affects how facial expressions are perceived.

For angry bodily expressions, a main effect of emotion was found, F (3.95, 486.2) =11.31, MSE =.008, p <.0001, $\eta^2 G$ =.07. Pairwise comparisons confirmed that neutral categorizations (8.06%) were made significantly more than fearful (3.13%), sad (1.9%), and surprised (1.8%) categorizations, *ps*<.002 (*Fig. 8*). Disgusted (5.14%) and happy (4.74%) categorizations were made significantly more than sad and surprised categorizations, *ps*<.04.

For disgusted bodily expressions a main effect of emotion was found, F (1.5, 185.1) =183.1, MSE =.065, p <.0001, $\eta^2 G$ =.57. Pairwise comparisons confirmed that fearful categorizations (42.94%) were made significantly more than surprised categorizations (13.61%), and both were made significantly more than all other incorrect categorizations (*ps*<.0001) (*Fig. 8*). A separate pairwise comparison confirmed there was no significant difference between accurate categorization (as disgusted) and incorrect categorization as fearful, p=1.

For fearful bodily expressions a main effect of emotion was found, F (2.39, 293.83) =27.48, MSE =.011, p <.0001, $\eta^2 G$=.15. Pairwise comparisons confirmed that surprised categorizations (9.1%) were made significantly more than disgusted (4.84%) categorizations

(p=.046) and both were made significantly more than all other incorrect categorizations (ps<.002) (*Fig. 8*).

For happy bodily expressions there was a main effect of emotion, F (1.87, 229.42) =84.31, MSE =.015, p <.0001, $\eta^2 G$=.37. Pairwise comparisons confirmed that surprised categorizations (15.93%) were made significantly more than all other incorrect categorizations, ps<.0001 (*Fig. 8*). Angry (2.82%) and neutral (2.32%) categorizations were made significantly more than fearful (0.3%) and sad (0.1%) categorizations, ps<.01 (*Fig. 8*).

For neutral bodily expressions a main effect of emotion was found, F (2.31, 284.07) =35.03, MSE =.008, p <.0001, $\eta^2 G$ =.19. Pairwise comparisons confirmed that sad categorizations (8.87%) were made significantly more than all other incorrect categorizations, ps<.0001 (*Fig. 8*). Angry categorizations (2.72%) were made significantly more than fearful categorizations (.71%), p=.043.

For sad bodily expressions a main effect of emotion was found, F (2.45, 300.74) =382.5, MSE =.013, p <.0001, $\eta^2 G$=.73. Pairwise comparisons confirmed that neutral categorizations (36.9%) were made significantly more than all other incorrect categorizations, ps<.0001 (*Fig. 8*). Disgusted (3.33%) and fearful (4.13%) categorizations were made significantly more than happy categorizations (1.12%), ps<.03 (*Fig. 8*).

For surprised bodily expressions a main effect of emotion was found, F (4.34, 534.83) =10.18, MSE =.015, p <.0001, $\eta^2 G$=.07. Pairwise comparisons confirmed that happy categorizations (13.1%) were made significantly more than disgusted (7.46%) and sad categorizations (3.02%), both ps<.006. Angry (8.97%), disgusted, fearful (9.38%), and neutral (9.78%) categorizations were made significantly more than sad categorizations, ps<.005 (*Fig. 8*).

In summary, angry bodily expressions were mostly confused as neutral and then as disgusted; disgusted expressions were confused as fearful as much as they were correctly categorized as disgusted and were next mostly confused as surprised; fearful and happy expressions were mostly confused as surprised; neutral expressions and sad expressions were mostly confused as each other; surprised expressions were mostly confused as happy expressions, and then were equally confused as 4 other mis-categorizations (angry, disgusted, fearful, and neutral). These confusions will be considered when interpreting the results of how context affects how facial expressions are perceived.

3.3 Facial Expression Categorization across Conditions

In this section the testing of the emotion seed hypothesis is broken down such that each facial expression makes up its own subsection. In each subsection, accurate recognition of facial expressions across conditions (8 conditions total: isolated face, congruent face-body condition and 6 incongruent face-body conditions) are reported first and are analyzed through a one way repeated measures ANOVA with condition as the independent variable (8 levels) and accuracy as the dependent variable. Pairwise comparisons verified which conditions beneficially/detrimentally impacted accuracy the most. The pairwise comparisons tested the prediction that congruent face-body expressions would be more accurately recognized than the facial expression presented in isolation (e.g. Meeren et al., 2005). Pairwise comparisons also tested the prediction that bodily expressions (i.e. those congruent to the facial expressions that the isolated target facial expression was perceptually similar to) should affect the accuracy of facial expressions in a stepwise fashion. The most perceptually similar facial expression's context should have the largest detriment to accuracy as compared to less perceptually similar facial expression's context. In addition unpredicted contexts should not affect the accuracy of the facial expression.

After accuracy is reported, mis-categorization analyses within the contexts predicted to affect categorization, are reported. These analyses were conducted to confirm that within a context the predicted effect occurs more than other mis-categorizations. Within-category analyses are broken up into one-way repeated measures ANOVAs with expression as the independent variable (6 levels) and mis-categorization as the dependent variable. Pairwise comparisons then confirmed whether the facial expression was mis-categorized more as a certain expression than other expressions in that context. The main prediction was that when a target facial expression was presented within a context emotionally congruent with what the isolated facial expression was perceptually similar to, the target expression should be mis-categorized as the perceptually similar expression more often in that context than in isolation.

Third, significant mis-categorizations within a condition are compared across all conditions using a one-way repeated measures ANOVA with condition as the independent variable (8 levels) and mean mis-categorization as a specific expression as the dependent variable. Pairwise comparisons determined whether the facial expression was mis-categorized more or not as a certain emotion in different contexts versus when presented alone. As well within a context the facial expression should not be more confused as a context incongruent emotion than it is in isolation. Between contexts the magnitude of effect should be as predicted (e.g. angry facial expressions should be more confused as disgusted in disgusted context than angry facial expressions are confused as sad in sad context). Predicted confusions that were significantly different from isolation were compared to one another to determine which confusion was largest. Since mis-categorizations differed in size in isolation, difference scores between the confusion in context versus the mis-categorization in isolation were computed and averaged. The mean of the difference scores were compared to determine which confusion was the largest overall. Due to the number of effects and mis-categorizations, only mis-categorizations larger than 5% and that are significantly different from at least one other mis-categorization are reported. Updated predictions for which contexts would affect categorization of facial expressions were based on similarity data from the isolated facial expression analysis in this study (Table 3).

In summary, several criteria must be met in order to satisfy assumptions made by the emotion seed hypothesis and they must be met for each basic emotion. A target facial expression should be more categorized as the context congruent facial expression and less accurately recognized in a context where it shares more perceptual similarity with the context's congruent facial expression as compared to a context where the target facial expression shares less perceptual similarity with the context's congruent facial expression. Similarly a target facial expression should also be more categorized as the facial expressions that it shares perceptual similarities with when presented in their contexts, than it is when presented in isolation. A target facial expression should also be less accurately recognized in predicted contexts than it is when presented in isolation. In addition correct categorization should not drop in contexts not predicted to have an effect on how the facial expression is perceived. Similarly mis-categorizations that are incongruent with the current context should not increase from what they are when facial expressions are presented in isolation.

Facial Expression	**Original Predictions (as in Table 1)**	**Present Study Similarity Data (and updated predictions)**
Angry	Disgusted > Sad > Neutral	Disgusted > Neutral > Sad
Disgusted	Sad > Angry > Fearful	Angry > Sad > Fearful
Fearful	Surprised > Sad > Happy	Surprised > Sad > Disgusted
Happy	Neutral > Fearful > Surprised	Neutral > Surprised > Fearful
Neutral	Happy > Angry > Sad	Angry > Happy > Disgusted
Sad	Disgusted > Fearful > Angry	Fearful > Disgusted > Surprised
Surprised	Fearful > Sad > Happy	Fearful > Sad > Happy

Table 3
Updated predictions for how facial expressions will be confused in context based on similarity data (i.e. facial expressions will be confused in the contexts to which they are perceptually similar to the context's emotionally congruent facial expression).

3.3a Categorization of Angry Facial Expressions across Conditions

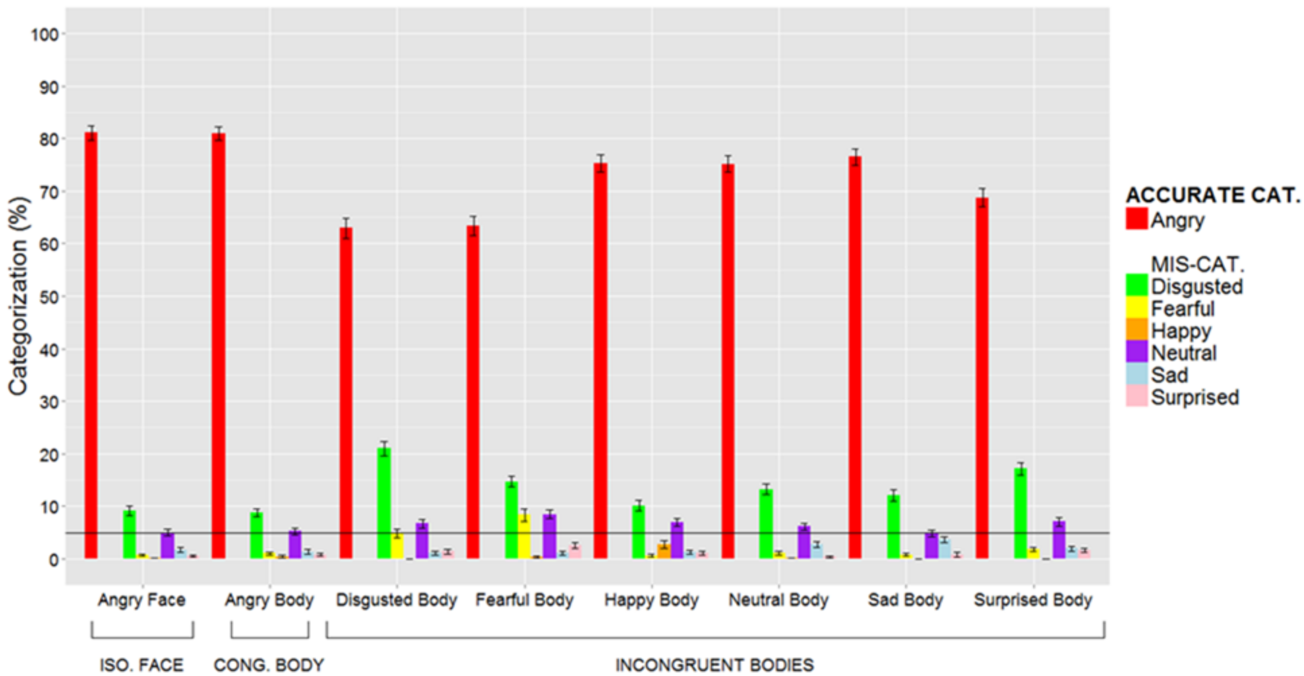


Figure 9
Emotion categorization for angry facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The red bars show the correct categorization as angry (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

The accurate recognition of angry facial expressions was compared across conditions to verify whether there was a congruency effect and which conditions affected accurate recognition the most (*Fig. 9, compare red bars*). There was a main effect of condition for the accurate categorization of angry faces, F (5.67, 700) =39.58, MSE=.02, p<.0001, η^2G=.12. Accuracy was not significantly different between the isolated face condition (81.15%), the congruent (81.05%), and sad (76.51%) face-body conditions (ps>.06). Accuracy was significantly lower for angry facial expressions when they were paired with disgusted (63.00%), fearful (63.41%), happy (75.3%), neutral (75.2%), and surprised (68.75%) bodies than when presented in isolation, all ps<.04. Disgusted and fearful contexts were not significantly different from one another but significantly affected the accuracy of angry facial expressions more than happy, neutral, sad, and surprised contexts, all *p*s<.03. Surprised context significantly affected the accuracy of angry facial expressions more than sad and neutral contexts (*p*s<.0002) which were not significantly different from one another (*p*=1).

Based on the similarity data obtained with isolated facial expressions, angry facial expressions were predicted to be confused with disgusted, neutral, and sad in disgusted, neutral, and sad contexts respectively. Therefore mis-categorizations within those three contexts were analyzed. A main effect of emotion was confirmed for angry faces in disgusted contexts, F (2.36, 289.67) = 98.77, *MSE*=.016, p<.0001, η^2G=0.40. Angry facial expressions were significantly more mis-categorized as disgusted (20.97%) than as any other emotion, all *p*s<0.0001. Neutral (6.75%) and fearful (4.83%) were the next largest mis-categorizations, not significantly different from one another (*p*=1), however significantly larger from the other three mis-categorizations, all *ps*<.003.

A main effect of emotion was confirmed in the neutral context F (2.41, 296.12) =80.12, *MSE*=.008, p<.0001, η^2G=0.35. Angry facial expressions were mis-categorized significantly more as disgusted (13.2%) and neutral (6.15%) (disgusted > neutral, p<.0001) in neutral contexts than all other mis-categorizations, all *ps*<.0004.

A main effect of emotion was confirmed for sad contexts, F (2.39, 293.82) = 55.8, *MSE*=.01, p<.0001, η^2G=0.27. Angry facial expressions were categorized significantly more as disgusted (12.01%) in sad contexts than all other mis-categorizations, all *ps*<0001.

Given that angry facial expressions were confused the most as disgusted and neutral each of these mis-categorizations were compared across conditions. A main effect of condition was confirmed for disgusted mis-categorization, F (6.01, 739.00) = 21.62, *MSE*=0.012, p<0.0001,

$\eta^2 G$= 0.1 (*Fig. 9, compare the green bars*). Angry facial expressions were categorized significantly more as disgusted in disgusted context (20.97%), in surprised context (17.13%), in fearful context (14.72%), and in neutral context (13.21%) than when angry facial expressions were presented in isolation (9.17%), all $ps<.009$. Mis-categorizations as disgusted were larger in the disgusted context than in the neutral and fearful body contexts (ps<.005) while there were no other significant differences in mis-categorization as disgusted between surprised, fearful, and neutral contexts (ps>0.06).

A main effect of condition was confirmed for angry faces mis-categorized as neutral, F (7, 861) =5, MSE=0.004, p<0.0001, $\eta^2 G$=.02 (*Fig.7, compare purple bars*). Angry facial expressions were mis-categorized as neutral significantly more in fearful contexts (8.46%) than when presented in isolation (4.93%, p=0.0015). Mis-categorization of angry facial expressions as neutral did not differ significantly when presented in isolation or when presented in neutral contexts (6.15%, p=1).

Thus, a congruency effect was not confirmed for angry facial expressions (i.e. accuracy for the correct categorization as anger was not larger in the context of an angry body compared to angry facial expressions presented in isolation). Unpredicted contexts (fearful, happy, and surprised) affected the accurate recognition of angry facial expressions. Angry facial expressions were most confused as disgusted in disgusted context and accuracy dropped the most in that context as predicted. Predicted confusions in sad and neutral context did not occur and while accuracy decreased for neutral context, accuracy in sad context did not decrease as compared to isolation. Angry facial expressions were more confused as disgusted in neutral, fearful, and surprised contexts than in isolation. These contexts were not predicted to increase the mis-categorization of angry faces as disgusted. Similarly angry facial expressions in fearful context were more confused as neutral than in isolation. In sum the emotion seed hypothesis cannot account for context incongruent confusions (e.g. angry confused more as disgusted in surprised context) or why accuracy decreased in unpredicted contexts.

3.3b Categorization of Disgusted Facial Expressions across Conditions

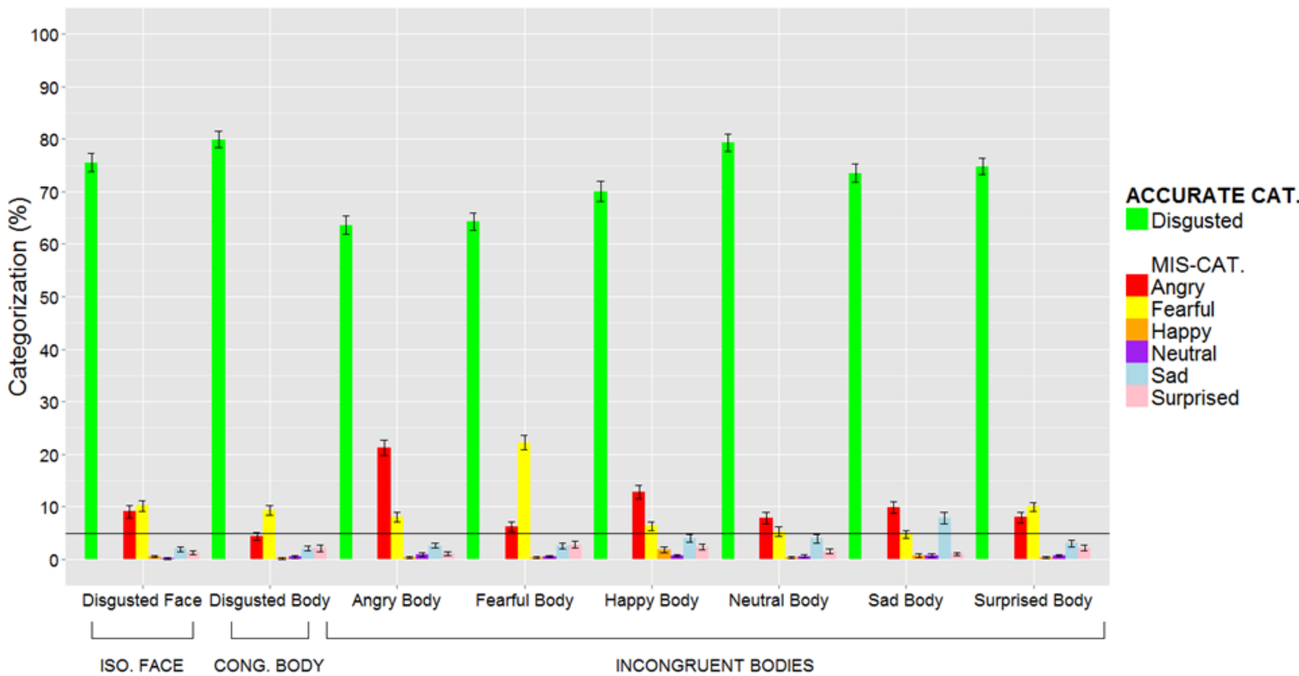


Figure 10
Emotion categorization for disgusted facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The green bars show the correct categorization as disgusted (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

There was a significant main effect of condition for disgusted faces accurately categorized as disgusted, F (7, 861) = 28.34, MSE=.017, p<.0001, η^2G=.085. There was no significant difference in correct categorization between the isolated face (75.5%) and the congruent (disgusted body) conditions (79.94%), p=1 (*Fig. 10, compare green bars*). Accuracy significantly decreased for angry (63.61%) and fearful body contexts (64.3%) as compared to the isolated condition, both ps<.0001 (angry and fearful not significantly different from one another,

p=1).Correct categorizations in happy, neutral, sad, and surprised contexts were not significantly different from correct categorization in the isolated face condition.

Disgusted facial expressions were predicted to be categorized more as angry, sad, and fearful when paired with angry, sad, and fearful contexts respectively. So mis-categorizations for the disgusted facial expressions within those contexts were analyzed. A main effect of emotion was confirmed for disgusted faces in angry context, F (2.01, 247.06) = 105.2, MSE=.02, p<.0001, $\eta^2 G$=0.43. Disgusted facial expressions were significantly more mis-categorized as angry (21.27%) and fearful (8.06%) (angry > fearful, p<.0001) than as any other emotion, ps<.0001.

A main effect of emotion was also confirmed in the fearful context, F (2.29, 282.14)= 111.7, MSE=.017, p<.0001, $\eta^2 G$=0.44. Disgusted facial expressions were significantly more mis-categorized as fearful (22.17%) and angry (6.25%) (fearful >angry, p<0.0001) than as any other emotion, ps<.04.

A main effect of emotion was confirmed for disgusted faces in sad context, F (2.88, 355.26) = 29.64, MSE=.012, p<.0001, $\eta^2 G$=0.17. Disgusted facial expressions were significantly more mis-categorized as angry (9.87%) in sad context than all other mis-categorizations except sad (7.86%), all significant ps<.007. Sad mis-categorizations occurred more than all other mis-categorizations except fearful (4.74%), all significant ps<.0001.

Mis-categorizations as angry, fearful, and sad were compared across conditions. A main effect of condition for angry mis-categorizations was confirmed, F (5.53, 680.2) =37.04, MSE=0.011, p<0.0001, $\eta^2 G$=0.13 (*Fig. 10, compare red bars*). Disgusted facial expressions were categorized as angry significantly more in the angry body context (21.27%) than in all other conditions, including when angry faces were presented in isolation (9.07%), *ps*<.0001. A main effect of condition for fearful mis-categorization was confirmed, *F* (5.29, 650.94) = 58.06, *MSE*=.009, *p*<.0001, $\eta^2 G$=.19 (*Fig. 10, compare yellow bars*). Disgusted facial expressions were categorized as fearful significantly more in fearful contexts (22.17%) than in any other condition, including when disgusted faces were presented in isolation (10.18%), *ps*<.0001. A main effect of condition for sad mis-categorization was confirmed, *F* (4.71, 578.78) = 12.03, *MSE*=.006, *p*<.0001, $\eta^2 g$=.06. (*Fig. 10, compare light blue bars*). Disgusted facial expressions were categorized as sad significantly more in sad contexts (7.86%) than in any other condition, including when disgusted faces were presented in isolation (1.92%), *ps*<.03.

Disgusted facial expressions categorized as angry in angry context, as fearful in fearful context, and as sad in sad context were confusions that were predicted to occur and so their difference means from those confusions in isolation were compared. A bonferroni corrected pairwise comparison confirmed that disgusted facial expressions categorized as angry in angry context (difference mean: 12.2%) and as fearful in fearful context (difference mean: 12%) were not significantly different from each other (*p*=1) but were significantly more confused than disgusted faces in sad context categorized as sad (difference mean: 5.9%), *p*s<.003.

Thus, a congruency effect for disgusted facial expressions was not confirmed. Disgusted facial expressions were confused most as angry, sad, and fearful in angry, sad, and fearful contexts respectively however the magnitude of the effects were not in line with predictions. The first (angry) and third (fearful) most similar facial expressions had equally large confusions while the second (sad) most similar facial expression had a smaller effect than the third most similar facial expression. As well accuracy did not decrease in a step wise fashion as predicted. Angry and fearful contexts reduced accuracy the most with sad contexts having no effect on accuracy. The emotion seed hypothesis fares well in explaining why the confusions occurred in certain contexts for disgusted facial expressions, however cannot explain why the magnitude of the confusions and accuracy differed from predictions.

3.3c Categorization of Fearful Facial Expressions across Conditions

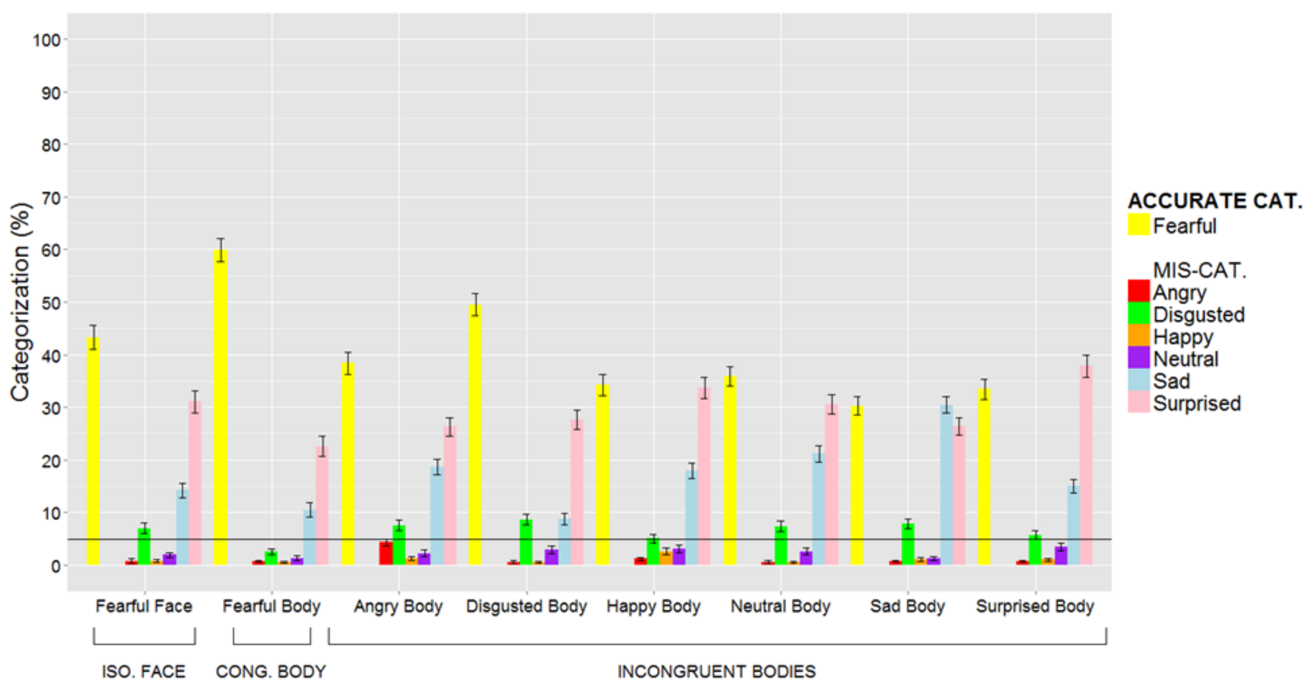


Figure 11
Emotion categorization for fearful facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The yellow bars show the correct categorization as fearful (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

There was a significant main effect of condition for the accurate categorization of fearful faces, F (6.17, 758.79)=50.47, MSE=0.024, p<0.0001, and $\eta^2 G$=0 .14. Accuracy was significantly higher when the fearful face was paired with a fearful body (congruent condition; 59.98%) compared to all other conditions, including isolated faces (43.24%), all ps<0.009 (*Fig. 11, compare yellow bars*). Accurate categorization was also higher in the disgusted body condition (49.5%) than all other incongruent conditions, ps<0.0001 (no significant difference from fearful facial expressions in isolation p=0.17). Accurate categorization was significantly lowered by happy (34.27%), neutral (35.88%), sad (30.24%) and surprised body contexts (33.47%) compared to the isolated face condition, all $ps<0.007$. Accuracy in sad contexts was significantly lower than accuracy in neutral contexts, $p=.011$.

Fearful facial expressions were predicted to be confused as surprised, sad, and disgusted in surprised, sad, and disgusted contexts, respectively. So mis-categorizations within those contexts were analyzed. A main effect of emotion was confirmed in disgusted context, F (2.17, 266.78) = 94.7, MSE=.032, $p<.0001$, $\eta^2 G$=0.40. Fearful facial expressions were significantly more often mis-categorized as surprised (27.62%), sad (8.77%), and disgusted (8.67%), (surprised>sad/disgusted, $ps<0.0001$; sad=disgusted, p=1), than as any other emotion, $ps<.0001$.

A main effect of emotion was confirmed in sad context, F (2.05, 252.74) = 154.5, MSE=.04, $p<.0001$, $\eta^2 G$=0.54. Fearful facial expressions were significantly more mis-categorized as sad (30.44%), surprised (26.4%), and disgusted (7.86%) (sad =surprised, p=1; sad and surprised> disgusted, $ps<0.0001$) than as any other expression, $ps<.0001$. Mis-categorizations as sad and surprised were not significantly different from accurate categorization (30.24%, both ps=1).

A main effect of emotion was also confirmed in surprised context, F (1.92, 236.55)= 147, MSE=.05, $p<0.0001$, $\eta^2 G$=0.52. Fearful facial expressions were significantly more often mis-categorized as surprised (37.90%), and sad (15.02%), (surprised>sad, $p<0.0001$), than as any other emotion, $p<.0001$. Mis-categorizations as disgusted (5.75%) were more frequent than two other mis-categorizations ($p<0.0001$). Mis-categorization as surprised was not significantly different from accurate categorization (33.47%, p=1).

Mis-categorizations as surprised, sad, and disgusted were compared across conditions. There was a main effect of condition for fearful faces mis-categorized as surprised, F (6.39, 786.15) =13.69, MSE=.023, p<.0001, η^2G= .043 (*Fig. 11, compare pink bars)*. Mis-categorizations as surprised were made more often in the surprised body context (37.90%) than all other contexts (except happy context (33.67%), p=.72*)* including when the facial expression was presented in isolation (31.05%), all significant *p*s<.02.

There was a significant main effect of condition for fearful faces mis-categorized as sad F*(*6.25,769.17)=47.14, MSE=.014, p<.0001., η^2G=.14 (*Fig. 11, compare blue bars)*. Mis-categorizations as sad were seen more often in sad body contexts (30.44%) than in all other conditions, including when the face was presented alone (14.21%, d=0.99), *ps*<.0001. Mis-categorizations as sad also occurred more often in angry (18.75%) and neutral (21.17%) body contexts than when the face was presented alone, all significant *ps*<.03.

A main effect of condition for fearful faces categorized as disgusted was also confirmed F *(*6.1, 750.52) = 6.93, MSE=.008, p<0.0001, η^2G=.03. Mis-categorizations of fearful faces as disgusted were seen less often in the fearful body context (2.52%; congruent condition) than in all other conditions including the isolated face condition (6.96%), all significant *ps*<.03. There was no significant difference in mis-categorization as disgusted when fearful faces were paired with disgusted bodies (8.67%) versus when presented in isolation, p=1.

Fearful facial expressions categorized as sad in sad context and as surprised in surprised context were confusions that were predicted to occur and so their difference means from those confusions in isolation were compared. A paired t-test confirmed that a fearful facial expression categorized as sad in sad context (difference mean: 16.23%) was significantly more of a confusion than as surprised in surprised context (difference mean: 6.85%), $t(123) = -3.91$, $SE = .023$, $p < .001$.

To summarize, fearful facial expressions demonstrated a congruency effect and were least accurately categorized when paired with happy, neutral, sad and surprised contexts. There was a larger decrease in accuracy in sad context than surprised context, counter to predictions, and happy and neutral contexts were not predicted to effect accuracy. For fearful facial expressions surprised and sad confusions were larger in sad and surprised contexts respectively than in isolation as predicted. However confusion as sad in sad context was larger than confusion as surprised in surprised context counter to predictions. Counter to predictions mis-categorization as disgusted was not significantly different between disgusted context and when the fearful face was presented in isolation. As well, accuracy in disgusted context was higher than in the other incongruent contexts. This can probably be explained by the fact that disgusted bodily expressions were equally recognized as fearful and disgusted. Context incongruent confusions also occurred with fearful facial expressions as they were more mis-categorized as sad in angry and neutral contexts than they were when presented in isolation. The emotion seed hypothesis explains why fearful faces are more confused as surprised and sad in surprised and sad contexts respectively. However the hypothesis can once again not account for magnitude differences in confusion or why unpredicted contexts affected accurate and inaccurate recognition of the facial expression.

3.3d Categorization of Happy Facial Expressions across Conditions

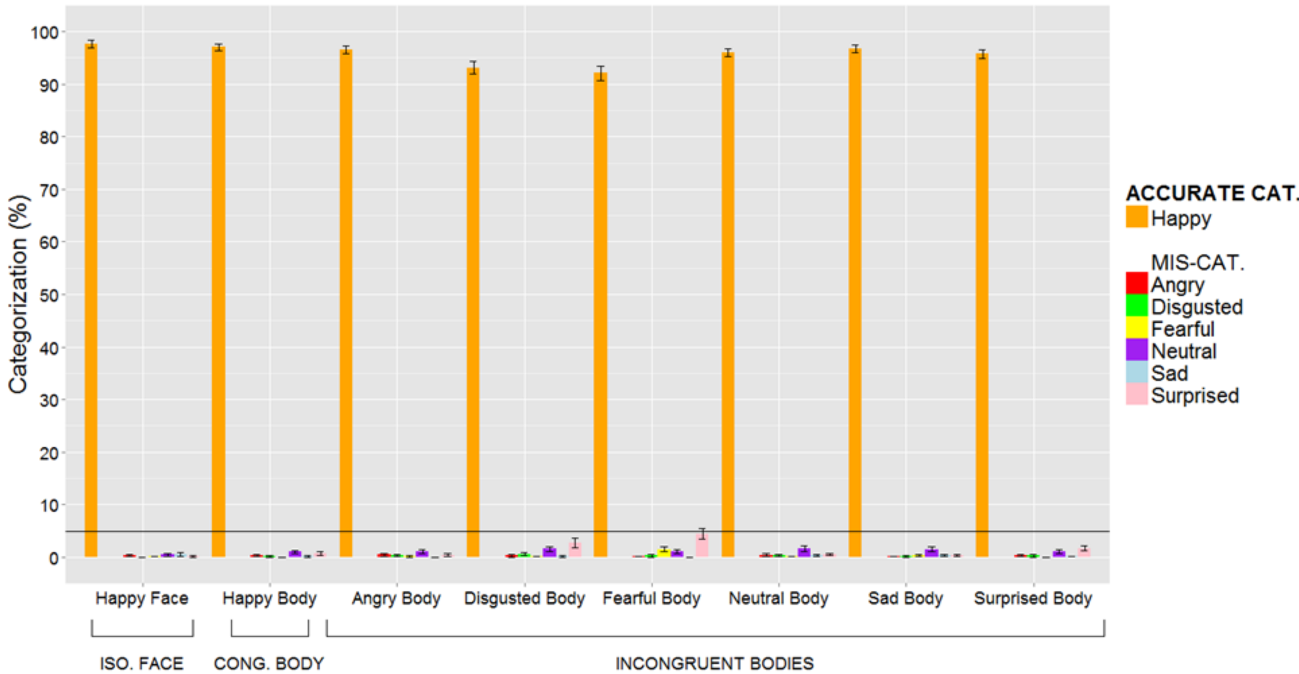


Figure 12
Emotion categorization for happy facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The orange bars show the correct categorization as happy (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

There was a significant main effect of condition for correct categorization of happy faces as happy, F (3.98, 489.73) = 7.18, MSE=.007, p<.0001, $\eta^2 G$=.032. Overall happy facial expressions were accurately categorized extremely well, with mean accuracies over 92% in all conditions (*Fig.12, compare orange bars*). Accurate categorization decreased significantly when happy facial expressions were paired with disgusted (93.14%) and fearful (92.14%) bodily expressions compared to when they were presented in isolation (97.6%), both ps<.03. There was no significant difference in accuracy when happy faces were presented in isolation versus when they were presented in happy context (97.08%), p=1. The predicted congruency effect for happy facial expressions was not confirmed. Counter to all predictions, happy facial expressions were not confused as any other expression and an unpredicted context (disgusted) affected how accurately the facial expression was perceived. Perhaps this is due to happy facial expressions being the only positively valenced expression in the set. However according to the emotion seed hypothesis this should not matter as happy facial expressions are perceptually similar to other presented facial expressions.

3.3e Categorization of Neutral Facial Expressions across Conditions

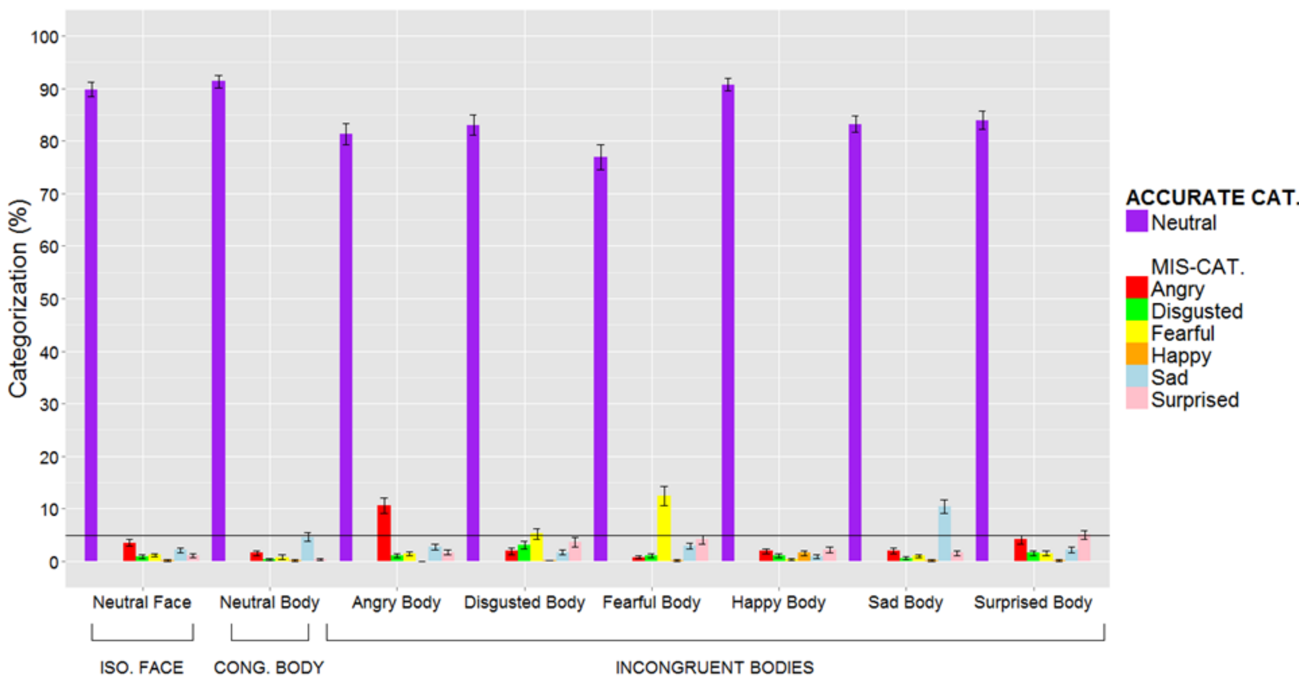


Figure 13
Emotion categorization for neutral facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The purple bars show the correct categorization as neutral (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

There was a significant main effect of condition for accurate categorization of neutral faces as neutral, $F(4.45, 546.95)= 19.73$, $MSE=.03$, $p<.0001$, $\eta^2G=.06$. Neutral expressions were best categorized when presented in isolation (89.82%), with a congruent neutral bodily expression (91.33%) and a happy bodily expression (90.73%) (no significant differences between all of them, all *ps*=1). Neutral facial expressions were less accurately categorized when paired with angry (81.35%), disgusted (83.06%), fearful (76.92%), sad (83.27%), and surprised contexts (83.97%) than when presented in isolation, all *ps*<.009 (*Fig. 13, compare purple bars*). Neutral facial expressions in fearful contexts were significantly less accurately recognized than when in disgusted and surprised contexts, *p*s<.005.

Neutral facial expressions were predicted to be more mis-categorized as angry, happy, and disgusted in angry, happy, and disgusted contexts than when presented in isolation. So mis-categorizations were analyzed within these contexts. There was a main effect of emotion in angry context, F (1.64, 201.89) = 33.87, *MSE*=0.017, p<0.0001, $\eta^2 G$=0.17 (*Fig. 13*). Neutral faces were mis-categorized as angry more often than as any other emotion (10.58%), *ps*<.0001. There was a main effect of emotion in happy context, F (4.06, 499.8) = 2.96, *MSE*=0.0024, p=.012, $\eta^2 G$=0.18 (*Fig. 13*), however no mis-categorizations were larger than 5%. There was a main effect of emotion in disgusted context, F (3.54, 435.3) = 6.95, *MSE*=.008, p<0.0001, $\eta^2 G$=.043 (*Fig. 11*). Neutral faces were mis-categorized as fearful (5.24%) more than as happy (0.1%) and as sad (1.71%), *ps*<.03.

Given that neutral expressions were most confused as angry and fearful in angry and disgusted contexts respectively, the mis-categorizations of neutral expressions as angry and fearful were compared across conditions. There was a significant main effect of condition for angry mis-categorization, F (2.6, 318.64) = 26.28, *MSE*=.012, p<.0001, $\eta^2 G$= .11 (*Fig. 11, compare red bars*). Neutral faces were mis-categorized as angry (10.58%) significantly more in angry context than in any other condition, including the isolated face condition (3.52%), all *ps*<.0002.

There was a significant main effect of condition for fearful mis-categorization, F (1.90, 233.72) =29.49, MSE=.026, p<.0001, $\eta^2 G$=.15 (*Fig. 13, compare yellow bars*). Neutral faces were categorized as fearful significantly more in fearful (12.64%) and disgusted (5.24%) contexts than in any other condition including neutral faces in isolation (1.38%), all ps<.02 (fearful context > disgusted context, p<.0001).

In summary, there was no congruency effect for neutral facial expressions and neutral facial expressions were less accurately recognized in all incongruent contexts except happy context. Neutral expressions were predicted to be less accurately recognized in angry, happy, and disgusted contexts (in increasing order of more accurate recognition). Neutral facial expressions were more confused as angry in angry contexts and as fearful in fearful/disgusted contexts versus when presented in isolation. Neutral was not predicted to be confused as fearful in either disgusted or fearful context and the categorization as fearful in fearful context was as large as the largest correctly predicted confusion (as angry in angry context). As well neutral facial expressions were not confused more as either happy or as disgusted in happy and disgusted contexts respectively as predicted. Again the emotion seed hypothesis cannot explain why unpredicted contexts affected accurate and inaccurate categorization of neutral facial expressions (i.e. fearful, sad, and surprised) or why predicted contexts (happy and disgusted) did not have their predicted effects.

3.3f Categorization of Sad Facial Expressions across Conditions

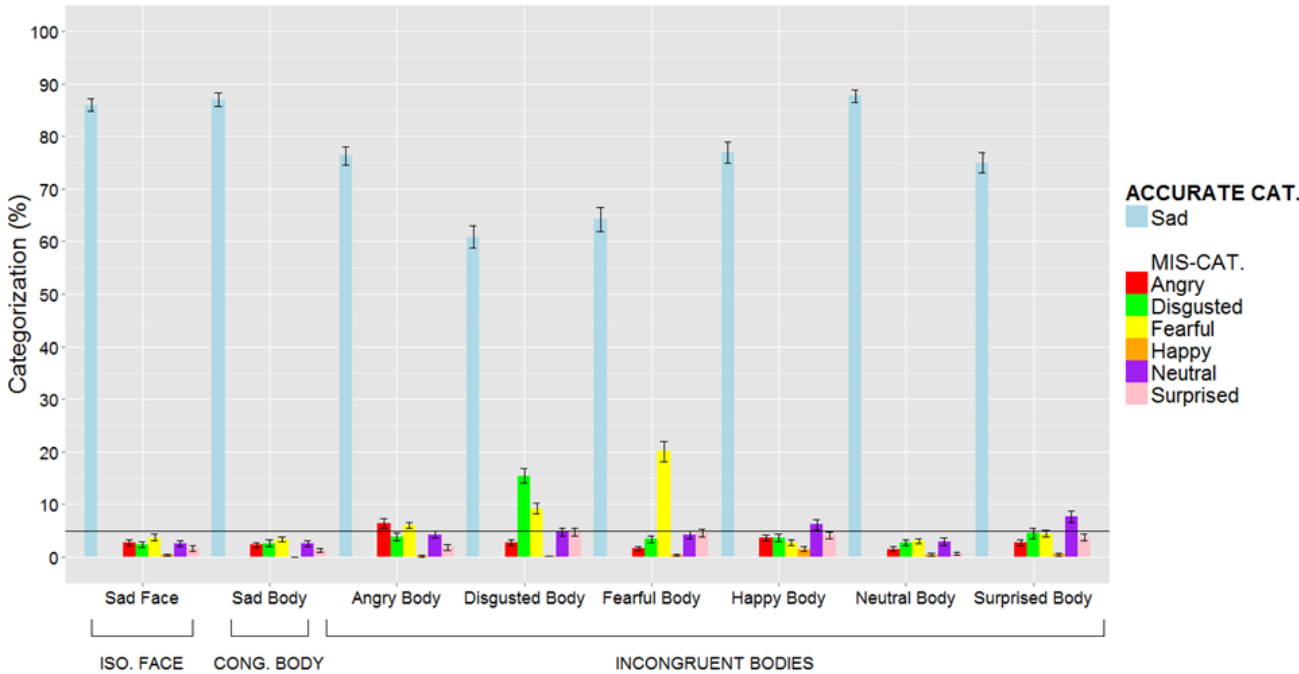


Figure 14
Emotion categorization for sad facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The light blue bars show the correct categorization as sad (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

As seen on Figure 14, there was a significant main effect of condition for the correct categorization of sad facial expressions, *F* (4.81, 591.87) =67.42, *MSE*=.028, *p*<.0001, $\eta^2 G$=.19. Correct categorization was not significantly different between the isolated face condition (85.99%), the congruent condition (87.00%), and the neutral condition (87.70%), all *ps*=1. Accurate categorizations in angry (76.31%), disgusted (60.88%), fearful (64.21%), happy (76.92%), and surprised (75%) contexts were significantly lower than when sad facial expressions were presented in isolation. Of these contexts disgusted and fearful contexts (disgusted = fearful, *p*=.65) were significantly different from angry, happy, and surprised contexts (angry = happy = surprised, all *ps*=1), all *ps*<.0001.

Sad facial expressions were predicted to be confused as fearful, disgusted, and surprised in fearful, disgusted, and surprised contexts respectively. Mis-categorizations within those contexts were analyzed. There was a main effect of emotion for sad faces in disgusted contexts, F (3.21, 395.25)= 40.98, MSE=0.014, p<.0001, $\eta^2 G$=0.22. Sad faces in disgusted contexts were significantly more mis-categorized as disgusted (15.42%) and fearful (9.17%) than as all other emotions, all ps<.0001 (disgusted > fearful, p<.006).

There was a main effect of emotion for sad faces in fearful contexts, F (1.91, 234.78) =58.6, MSE=0.029, p<.0001, $\eta^2 G$=0.29. Sad faces in fearful contexts were significantly more mis-categorized as fearful (20.06%) than as any other emotion, all ps<.0001.

There was a main effect of emotion for sad faces in surprised contexts, F (3.47, 426.3) =10.12, MSE=0.01, p<0.0001, $\eta^2 G$=0.06. Sad faces were mis-categorized significantly more as neutral (7.66%) than as angry (2.72%), happy (0.5%), and surprised (3.73%), ps<.04.

Categorization of sad faces as disgusted, fearful and neutral were compared across conditions as these were the most used mis-categorizations for sad facial expressions. There was a significant main effect of condition for disgusted mis-categorization, F (3.81, 468.37) = 42.34, MSE=.006, p<.01, $\eta^2 G$=0.17 (*Fig. 14, compare green bars*). Sad facial expressions were significantly more categorized as disgusted (15.42%) in a disgusted context than in any other context, including when sad facial expressions were presented in isolation (2.42%), all ps<0.0001.

There was a significant main effect of condition for sad faces mis-categorized as fearful, F (2.61, 321.40) = 47.21, MSE= 0.024, p<.0001, $\eta^2 G$= .23 (*Fig. 14, compare yellow bars*). Sad facial expressions were significantly more mis-categorized as fearful in fearful (20.06%) and disgusted (9.17%) contexts than in all other contexts (except for a non-significant difference between disgusted and angry (6.05%) contexts, p=.19), including sad faces in isolation (3.73%), all significant *ps*<.0007.

A main effect of condition for sad faces mis-categorized as neutral was confirmed, F (5.5, 675.57) =7.76, *MSE*=0.007, $p<0.0001$, η^2G=0.036. Sad faces were categorized as neutral significantly more in happy (6.14%) and surprised (7.66%) contexts than when presented in isolation (2.62%), both *ps*<0.02, or when presented in any other context.

Sad facial expressions categorized as fearful and disgusted in fearful and disgusted contexts respectively were confusions that were predicted to occur and so their difference means from those confusions in isolation were compared. A paired t-test confirmed that a sad facial expression categorized as fearful in fearful context (difference mean: 16.33%) was not significantly different from confusion as disgusted in disgusted context (difference mean: 13.00%), t (123) = 1.6, *SE*=.021, *p=.112.*

In summary, counter to predictions a congruency effect for sad facial expressions was not confirmed. Accurate categorization of sad faces decreased in all incongruent contexts except neutral body context. Accuracy dropped the most in fearful and disgusted contexts as compared to all other contexts. Sad expressions were predicted to be less accurately recognized in fearful, disgusted, and surprised contexts (in increasing order of more accurate recognition). Sad facial expressions were more categorized as disgusted/fearful, fearful, and neutral (a facial expression it is not perceptually similar to) expressions in disgusted, fearful, and surprised/happy contexts respectively than they were in isolation. There was no difference between the confusion as fearful in fearful context and the confusion as disgusted in disgusted context and there was no confusion as surprised in surprised context. The emotion seed hypothesis predicted the confusions as disgusted and as fearful in disgusted and fearful contexts respectively but the expected magnitude differences were absent. As well the hypothesis cannot account for context incongruent confusions in three separate contexts and accuracy dropping in two unpredicted contexts.

3.3g Categorization of Surprised Facial Expressions across Conditions

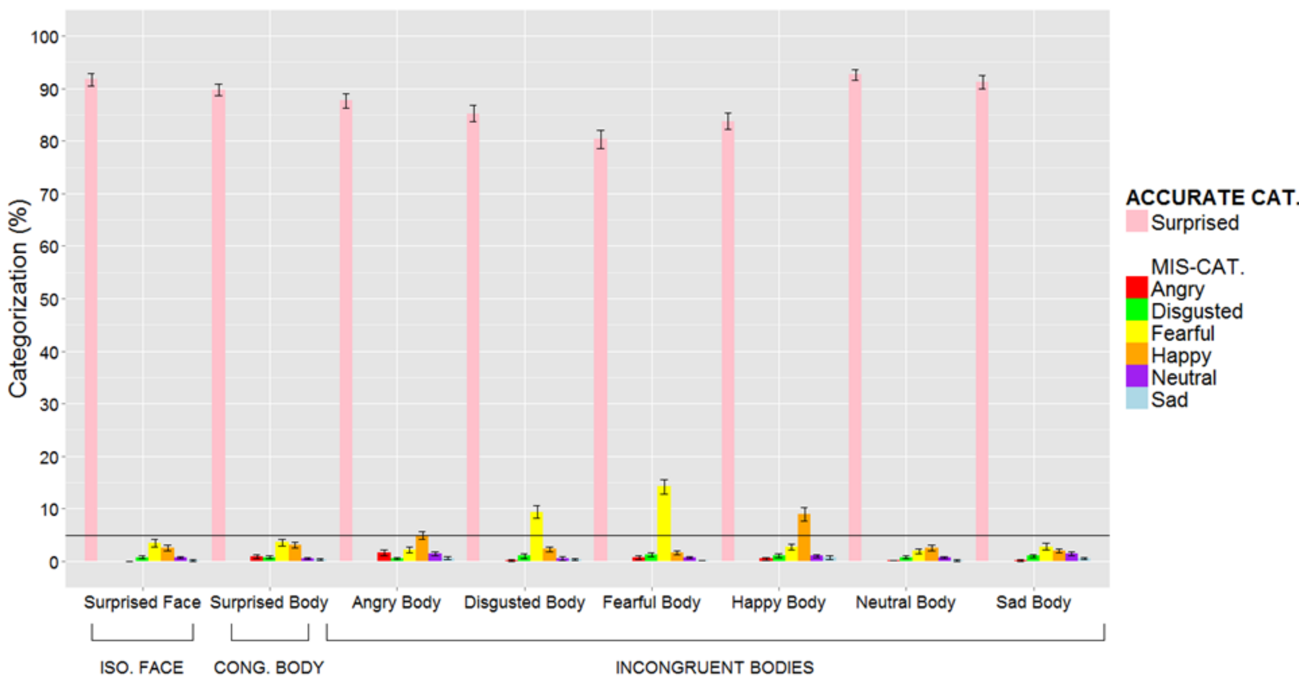


Figure 15
Emotion categorization for surprised facial expressions across the 8 conditions (the isolated face, the congruent face-body and the 6 incongruent face-body conditions). The pink bars show the correct categorization as surprised (Accurate Cat. =Accurate Categorization). The other coloured bars show the incorrect categorizations as the other possible emotions or neutral (Mis-Cat.=Mis-categorization).

There was a significant main effect of condition for the correct categorization of surprised facial expressions as surprised, F (5.64, 694.9) = 17.49, MSE=.017, p<0.0001, $\eta^2 G$=.066. Surprised facial expressions were equally accurately categorized when they were presented in isolation (91.73%), congruent context (89.91%), angry context (87.7%), neutral context (92.64%) and sad context (91.22%), and all ps>.09. Accurate categorization of surprised facial expressions decreased in disgusted (85.28%), fearful (80.34%), and happy (83.77%) contexts compared to when surprised facial expressions were presented in isolation, all *ps*<0.0009. Accuracy in fearful context was significantly lower than in disgusted context, *p*=.0486.

Surprised facial expressions were predicted to be most mis-categorized as fearful, sad, and happy in fearful, sad, and happy contexts respectively. Thus mis-categorizations within these conditions were compared. A main effect of emotion was confirmed for mis-categorization of surprised faces in sad contexts, F (3.15, 387.33) = 7.11, *MSE*=0.003, $p<0.0001$, η^2G= 0.042, however no mis-categorizations were larger than 5%. A main effect of emotion was confirmed for mis-categorizations of surprised faces in fearful contexts, F (1.38, 170.34) = 73.42, *MSE*=0.018, $p<0.0001$, η^2G= 0.33 as surprised faces were significantly more miscategorised as fearful (14.21%) than as any other emotion, all *ps*<0.0001. A main effect of emotion was confirmed for mis-categorizations of surprised faces in happy contexts, F (2.06, 253.05) =28.55, *MSE*=0.011, $p<0.0001$, η^2G= 0.16. Surprised faces were significantly more miscategorised as happy (8.97%) in happy contexts than as any other emotion, all *ps*<0.0003.

Categorization as fearful and happy were compared across all conditions as they were the most used mis-categorization terms for surprised facial expressions in fearful and happy contexts. There was a main effect of condition for surprised faces mis-categorized as fearful, F (3.28, 403.92) = 35.57, *MSE*=.014, $p<.0001$, η^2G=.16 (*Fig. 15, compare yellow bars*). Surprised facial expressions were mis-categorized as fearful significantly more when presented in a fearful (14.21%) and disgusted (9.38%) context (fearful context > disgusted context, p=.007) than in any other condition, including the isolated surprised face condition (3.43%), all *ps*<.0003.

There was a significant main effect of condition for surprised faces mis-categorized as happy, F (3.63, 447.09) =17.36, *MSE*=.008, p<.0001, $\eta^2 G$= .09 (*Fig. 15, compare orange bars*). Surprised facial expressions were mis-categorized as happy (8.97%) significantly more in happy context than in any other condition, including isolated surprised face condition (2.52%), all *ps*<.02.

Surprised facial expressions categorized as fearful and happy in fearful and happy contexts respectively were confusions that were predicted to occur and so their difference means from those confusions in isolation were compared. A paired t-test confirmed that a surprised facial expression categorized as fearful in fearful context (difference mean: 10.79%) was a significantly larger confusion than as happy in happy context (difference mean: 6.45%), t (123) = 2.64, *SE*=.016, p=.009.

In summary there was no congruency effect for surprised facial expressions. Surprised faces were less accurately categorized in disgusted, fearful, and happy contexts but not in sad contexts (as predicted). Accuracy was lower in fearful context than happy context as predicted, however an unpredicted context (disgusted) equally affected accuracy as much as fearful context. Surprised facial expressions were not confused as sad in sad context. Confusion as fearful in fearful context was larger than confusion as happy in happy context (as predicted), however confusion as happy was as large as a confusion as fearful in disgusted context, a context that was not predicted to elicit any particular confusion. The emotion seed hypothesis predicted the confusions as fearful and happy as well as their differences in magnitude but predicted changes in sad context were not found. The unpredicted confusion and accuracy drop in disgusted contexts may be due to disgusted bodily expressions being accurately categorized as disgusted and mis-categorized as fearful equally.

4 Discussion

The categorical perception of a facial expression can be altered by which context it is paired with. However it remains unclear as to how context could modulate the perceived category of a facial expression. Recently the emotion seed hypothesis has accumulated evidence in its support but remains to be fully tested. The hypothesis predicts that a target facial expression is confused in context as a function of how similar the target facial expression is to the context congruent facial expression. This study was the first to exhaustively present all possible combinations of the six basic emotions and neutral expressions displayed by the face and the body, to confirm whether or not the emotion seed hypothesis is emotion dependent (i.e. that it only explains why some emotions are confused in context).

Isolated facial and bodily expressions as well as their combinations were presented to participants. Perceptual similarity, likely to be database dependent, was determined with an MDS plot where distances between facial expressions determined similarity between the facial expressions, like in Susskind and others (2007). Categorizations of isolated facial expressions were compared to categorizations of the facial expressions in different contexts to determine how context affected how the facial expression was perceived. The main measure was whether the facial expression was more mis-categorized as a certain expression when presented in a given context compared to in isolation. Facial expression confusion and accuracy was predicted to follow a gradation such that the more similar a target facial expression was to the context congruent facial expression, the more the target facial expression should be categorized as the context congruent facial expression and the less accurately it should be recognized. Bodily expressions were presented in isolation as they had not previously been fully validated and to ensure that they were expressing the emotions they were intended to express. A secondary goal of this study was to fully validate all isolated bodily expressions of the six basic emotions and neutral for accurate and inaccurate responses.

4.1 Accurate and Inaccurate Recognition of Isolated Facial Expressions

Happy expression is generally the best recognized facial expression whereas disgusted and fearful expressions are generally the worst recognized (e.g. Calvo & Lundqvist, 2008; Tottenham et al., 2009; Goeleven et al., 2008; Ebner et al., 2010; Palmermo & Coltheart, 2004; Langer et al., 2010; Du & Martinez, 2011), a pattern which was replicated here as predicted (see Table 4 for order of accurate recognition from Tottenham et al., 2009 and this study). While neutral, sad, and surprised facial expressions differed in order of accurate recognition from predictions they were rather close to predictions in terms of accurate recognition (i.e. the percentages were similar; Tottenham et al., 2009). Angry facial expressions were predicted (e.g. Tottenham et al., 2009) to be the second best accurately recognized facial expression, but were one of the three worst recognized. Interestingly, fearful and angry faces in the present study were much worse recognized than in the validation study.

These differences possibly stem from differences in the size of the presented facial expression images as this changed the most between the current study and the NIMSTIM study. One study that varied the sizes of different presented dynamic emotional facial expressions found that image size did not impact how well the expression was recognized until the image size was extremely small (less than 2 degrees of visual angle) (Cunningham et al., 2004). However it remains to be seen how variations in size of static isolated facial expressions affects the accurate recognition of facial expressions as it is likely that motion played a role in helping participants to identify the correct emotion (Alves, 2013) despite differences in image size. It is also unclear as to why recognition of other facial expressions was not affected by the reduction in size. It's possible that some facial expressions are more affected by changes in size than other ones, as some facial expressions may need to be seen up close in order to determine what an individual is expressing. Overall this data matches predictions and data from previous validations of other facial expression databases well (Calvo & Lundqvist, 2008; Tottenham et al., 2009; Goeleven et al., 2008; Ebner et al., 2010; Palmermo & Coltheart, 2004; Langer et al., 2010; Du & Martinez, 2011).

Order of Accurate Facial Expression Recognition	**Tottenham et al., 2009 (Predictions) (NimStim database)**	**Present Study (Data) (NimStim database)**
First	Happy (98.5%)	Happy (97.5%)
Second	Angry (93.75%)	Surprised (91.7%)
Third	Neutral (90.38%)	Neutral (89.8%)
Fourth	Surprised (87.5%)	Sad (86%)
Fifth	Sad (83%)	Angry (81%)
Sixth	Disgusted (83%)	Disgusted (75.5%)
Seventh	Fearful (66%)	Fearful (43%)

Table 4
Order of accurate facial expression recognition. The first column are the predictions from the NIMSTIM validation (percentages based on the subset of the database that was used in the present study), and the second column is the order obtained in the present study.

There were a number of differences between what facial expressions were predicted to be most, moderately and least similar to and what they were actually most, moderately, and least similar to (Table 3, see pg. 42). Confusion data for individual stimuli were not available, so the average confusion data from all NIMSTIM stimuli were used to make the predictions. Differences between predictions and results likely stem from the particular subset of stimuli that were used from the entire NIMSTIM database. Stimulus dependent results, long a concern in the field of facial expression perception, are poignantly apparent between a subset of a set of stimuli and the set as a whole. This suggests that these differences must be taken into account in all studies of facial expression perception especially when different databases are used. Unfortunately stimulus dependent results were not taken into account in any of the previously mentioned studies done by the Mondloch group (Mondloch, 2012; Mondloch et al., 2013a; Mondloch et al., 2013b). The emotion seed hypothesis was tested using facial expressions pulled from the NIMSTIM database, but using the predictions from Susskind and others (2007) based on a different database. This puts conclusions drawn by the Mondloch group in their three studies of the emotion seed hypothesis in jeopardy as they did not take into account stimulus dependent results of their own stimuli.

4.2 Accurate and Inaccurate Recognition of Isolated Bodily Expressions

Essentially this was the first study to fully validate accurate and inaccurate recognition of isolated bodily expressions for each basic emotion and neutral, as each stimulus was categorized multiple times and there were 7 categorization options. In the original study all bodily expressions were impressively better recognized than they were in the present study. These differences can likely be explained by the fact that in the validation study the bodily expressions were paired with their congruent facial expressions, whereas in the present study only the isolated bodily expressions were presented (Table 5). In two of the other previously mentioned isolated bodily expression databases, the bodily expressions were also highly accurately recognized (Thoma et al., 2013; De Gelder et al., 2011). In the BESST database all basic emotions were presented but participants only had two categorization options to choose from when categorizing each stimulus, likely inflating the accuracy with which they were going to recognize the particular expression (Thoma et al., 2013). As well the BEAST database only presented four bodily expressions with 4 categorization options, again potentially inflating the accuracy with which participants recognized the emotions (De Gelder et al., 2011). Accuracy in the Atkinson and others 2004 study for five basic bodily expressions with five categorization options was much lower than in either the BESST or BEAST database. While it is not clear why some of the bodily expressions (e.g. angry) were so poorly recognized (perhaps caliber of actor or chosen poses) it is clear that there is a lot of variability in accurate recognition between bodily expressions. At the very least to fully validate stimuli for these purposes, multiple if not all of the basic emotions and neutral should be used as well as a large number of categorization options.

The analysis of bodily expression (Table 6) confusion was exploratory especially due to the lack of previous isolated bodily expression studies. As well given the limited categorization options in previous studies it is difficult to compare this data to the literature that does exist (Thoma et al., 2013; de Gelder et al., 2011; Atkinson et al., 2004). Interestingly, some bodily expressions were more subject to confusion than other bodily expressions much like facial expressions. Some bodily expressions such as fearful and neutral were reliably recognized whereas disgusted, sad, and surprised bodily expressions were heavily confused. It is likely that disgusted and sad bodily expressions share a lot of perceptual similarities with fearful and neutral bodily expressions respectively as they were equally categorized as these expressions. It would be interesting to further explore whether bodily expressions are confused for one another based on perceptual similarity. More data and bodily expression stimuli are needed to determine whether this order of accurate recognition and the confusions for isolated bodily expressions are a general trend or if there are some bodily expressions (e.g. disgusted) that could be better posed (i.e. more accurately recognized and less confused as another expression). At the very least this study demonstrates that there are reliable ways in which to express certain emotions (e.g. fearful) using bodily expressions, echoing previous claims (de Gelder et al., 2012).

Order of Accurate Bodily Expression Recognition	**Schindler et al., 2008 (Predictions)**	**Present Study (Data)**
First	Happy (98%)	Neutral (84.9%)
Second	Neutral (96%)	Fearful (80.4%)
Third	Fearful (88%)	Happy (76%)
Fourth	Sad (87.5%)	Angry (72.6%)
Fifth	Surprised (84%)	Sad (47.9%)
Sixth	Angry (80%)	Surprised (44.4%)
Seventh	Disgusted (78%)	Disgusted (38.4%)

Table 5
Presents the predicted order of accurate recognition of bodily expressions from the validation study and the actual order from this data set.

Bodily Expression	**Present Study (Data)**
Angry	Neutral (8.06%) > Disgusted (5.14%)
Disgusted	Fearful (42.94%) > Surprised (13.61%)
Fearful	Surprised (9.1%)
Happy	Surprised (15.93%)
Neutral	Sad (8.87%)
Sad	Neutral (36.9%)
Surprised	Happy (13.1%)> Angry (8.97%) = Disgusted (7.46%) = Fearful (9.38%) = Neutral (9.78%)

Table 6
Bodily expression confusion data from the present study.

4.3 Accurate Recognition of Facial Expressions across Conditions

Facial expressions congruently paired with bodily expressions were predicted to be more accurately recognized than when the facial expression was presented alone, assuming that bodily expressions were recognized mostly as the intended emotion. These predictions were based on previous data that demonstrated that congruency effects for facial expressions (i.e. reduced reaction times and increased accuracy) occurred in all different types of context (e.g. Righart &

de Gelder, 2008, Meeren et al., 2005, de Gelder & Vroomen, 2000). Congruency effects have been shown for angry, disgusted, fearful, and sad facial expressions paired with angry, disgusted, fearful, and sad bodily expressions respectively (Meeren et al., 2005; Aviezer et al., 2012c; Mondloch, 2012; Mondloch et al., 2013a; Mondloch et al., 2013b).

In the present study, only fearful facial expressions demonstrated a boost in accuracy when paired with a congruent bodily expression. There were no significant differences in accuracy between any of the other congruently paired facial expressions versus when they were presented in isolation. The congruency effect likely occurred for fearful facial expressions as they were poorly recognized in isolation and the bodily expression was highly accurately recognized. However even when paired with congruent bodily expressions, fearful facial expressions were still only accurately recognized at a mean of ~60%, which is still less than all of the other facial expressions presented in isolation. Other bodily expressions were recognized mostly as intended (e.g. angry and neutral) however these bodily expressions did not lead to a congruency effect. Some bodily expressions were recognized equally as intended and as another emotion (e.g. disgusted confused as fearful). Perhaps if disgusted bodily expressions were better recognized then there would have been a congruency effect for disgusted faces as these were the next worse recognized facial expression.

In all previously cited studies where bodily expressions and facial expressions were congruently paired, isolated bodily expressions were accurately categorized over 85% (Mondloch et al., 2013a; Mondloch, 2012; Mondloch et al., 2013b, Aviezer et al., 2008; Meeren et al., 2005). Yet no bodily expression in this study was accurately recognized over 85%. Therefore perhaps more accurate recognition of bodily expressions or contexts is needed for a congruency effect to occur. Further research is warranted to determine the interplay of accurate facial and bodily expression recognition that is needed in order to demonstrate congruency effects.

For almost all facial expressions at least one unpredicted context affected how accurately the facial expressions were perceived (e.g. sad in happy contexts were less accurately recognized than sad facial expressions in isolation). As well accurate categorization did not decrease in a linear fashion for all three levels of perceptual similarity for any facial expression. Accuracy drops in unpredicted contexts effects could have occurred due to a general incongruency effect, such that facial expressions that are incongruently paired are less accurately recognized overall. However this would not explain why this did not occur each time a facial expression was incongruently paired. It is more likely that underlying dimensions such as valence or intensity also played a role in how facial expressions were categorically perceived.

4.4 Incongruently Paired Facial and Bodily Expressions

Overall there were a number of effects that the emotion seed hypothesis did not account for and it was not successful in explaining all the effects for any of the facial expressions. Context incongruent confusions (e.g. angry face being categorized as neutral more in fearful context than in isolation) represent the most troubling effect for the hypothesis as facial expressions are predicted to be strictly confused as the context expression and not any other expressions. In the case where a facial expression was confused as another expression in the fearful context it was also generally confused, to a lesser extent, as that same emotion in the disgusted context (e.g. sad being confused as fearful in fearful and disgusted contexts). This effect was most likely due to disgusted bodily expressions being equally categorized accurately (i.e. as disgusted) and as fearful. However a similar explanation is not apparent for angry and sad facial expressions being more confused as neutral in incongruent contexts. Only surprised bodily expressions were confused as neutral, which may explain why sad facial expressions were more confused as neutral in surprised context than in isolation. But this doesn't explain why this confusion occurred in happy or fearful context for sad and angry faces respectively. It also does not explain why these expressions were not more confused in neutral context than in isolation. Perhaps in order for a facial expression to be confused as another facial expression the context that the facial expression is paired with must have some emotionality to it such as valence or intensity (which neutral context would lack). This interpretation however is clouded by the fact that angry expressions were more confused as disgusted in neutral context than they were in isolation.

The predicted linear effect of contexts having more or less of an effect on the categorization of a facial expression depending on facial expression similarity, rarely worked out as predicted. For example fearful facial expressions were predicted to be more confused as surprised in surprised context than as sad in sad context, but sad confusions were larger and fearful and surprised bodily expressions were similarly accurately recognized. The unpredictability of this effect is hard to reconcile with the emotion seed hypothesis, as it is at the core of the hypothesis.

Lastly all facial expressions, except happy, were confused more as their most similar facial expressions in the respective context but only some were confused as their second most similar facial expression in the respective context. It rarely occurred that the facial expression was more confused as the third most similar facial expression in the predicted context. Indeed happy facial expressions were not confused in any context. Happy was the only positively valenced facial expression in this study as is common in facial expressions studies (e.g. Tottenham et al., 2009). This most likely played a large role in making the facial expression noticeably distinct from the other facial expressions. Further studies should incorporate more positively valenced facial and bodily expressions in order to test if the perception of happy facial expressions can be modified by context when positively valenced expressions are included. Happy facial expressions not being confused in any context and other facial expressions being most confused in the predicted context suggest that both valence and facial similarity play a role in how context modulates the perceived category of a facial expression. In sum the emotion seed hypothesis weakly describes some of the observed effects and fails to account for effects outside of its limited scope. It is time to look at the interplay of categorical perception and underlying dimensionality in order to understand how context can alter the perception of a facial expression.

4.5 Comparison to Aviezer and others' studies

A number of methodological differences between this study and those performed by Aviezer et al., 2008 could explain the differences in the extent of context effect seen between the two sets of studies, including differences in context stimuli recognition and differences in how many different emotional expressions participants saw. The contexts that Aviezer and others used combined paraphernalia or scene combined with bodily expression such that the contexts were not purely bodily expression and most likely the scene/paraphernalia aided ceiling recognition for all pure context images (all above 90%). None of the pure bodily expressions utilized in this present study were recognized at ceiling (all below 90%) and some were extensively confused with another emotion (e.g. neutral, *Fig. 8*). Therefore in this study some bodily expressions were more confusable than others whereas in the Aviezer study the paraphernalia ensured that the context could only be perceived in one way. Another important methodological difference was the combination of all basic emotions and neutral facial and bodily expressions in this set of studies whereas in Aviezer et al. (2008) one facial expression (i.e. disgust) was presented in 4 different contexts (Aviezer et al., 2008). The lack of different facial emotional expressions and the fact that there were six options from which to choose to label the facial expressions may have led participants to expect different facial expressions and therefore influence their perception of the presented facial expressions. Granted in subsequent studies from the same group, the designs were more balanced (4 facial expressions x 4 bodily expressions) however results were difficult to compare as only accuracy was reported rather than overall categorization data (Aviezer et al., 2012). Or categorization data was aggregated and averaged into four different groups as a function of how similar a target facial expression was to the context congruent facial expression (i.e. identity, high similarity, medium similarity, and low similarity) (Aviezer et al., 2011).

4.6 Limitations

A number of caveats are worth mentioning which may limit the generalizability of the findings. For one forced choice methodology with seven response options limited and artificially constrained how facial and bodily expressions could be perceived, perhaps also leading to artificial consensus on what the expressions were emoting. This could be addressed in future studies by using various methods of response methodology such as by comparing two facial expressions in context at the same time and tasking participants to determine whether they are the same expression. Participants should be more inaccurate in their comparisons when one of the facial expressions or both are paired with a context in which the facial expression is highly confused as another expression. As well Likert dimensional scales could be used to rate facial expressions on dimensionality of valence and intensity to test how the dimensionality of a context may affect facial expression perception.

Secondly participants saw hundreds of still, mostly de-contextualized, and highly expressive photographs of different expressions one after another on a computer screen. Despite these conditions which, by their very nature encourage categorical recognition of facial expressions, facial expression perception could be modulated as a function of what bodily expression a facial expression was paired with. One way to increase ecological validity while maintaining experimental control, would be to present three-dimensional computer generated facial expressions modelled after spontaneous expressions of emotion via virtual reality. Future studies could also include more positively valenced facial expressions to test whether happy facial expressions are really recognized at ceiling or whether it is an artefact of happy faces being the only positively valenced expression.

4.7 Summary and Future Directions

Facial expression perception is context variant and the emotion seed hypothesis is inadequate in explaining how categorical facial expression perception is altered by bodily context. While some of the context effects can be explained by perceptual similarity between facial expressions (e.g. angry confused more as disgusted in disgusted context) it cannot explain why some facial expressions were confused as context incongruent expressions. The next step would be to run the same study but to ask participants to rate the stimuli on dimensional scales of valence (i.e. positivity/negativity of an emotion) and intensity to see how context may have dimensionally affected the facial expressions to bring them to be categorized as different emotions. A broader theory of facial expression perception must be able account for why facial expression and bodily context are processed holistically (Aviezer et al., 2012c), rapidly (around the same time) (Van den Stock et al., 2007), regardless of instructions (Van den Stock et al., 2007, Avizer et al., 2011), and why they influence the perception of one another (de Gelder, 2009). Indeed it may be more prudent to develop a more general theory of emotional signals, as many emotional signals have been shown to display similar characteristics (Wieser and Brosch, 2012).

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Appendix

Facial Expression Categorization Percentages

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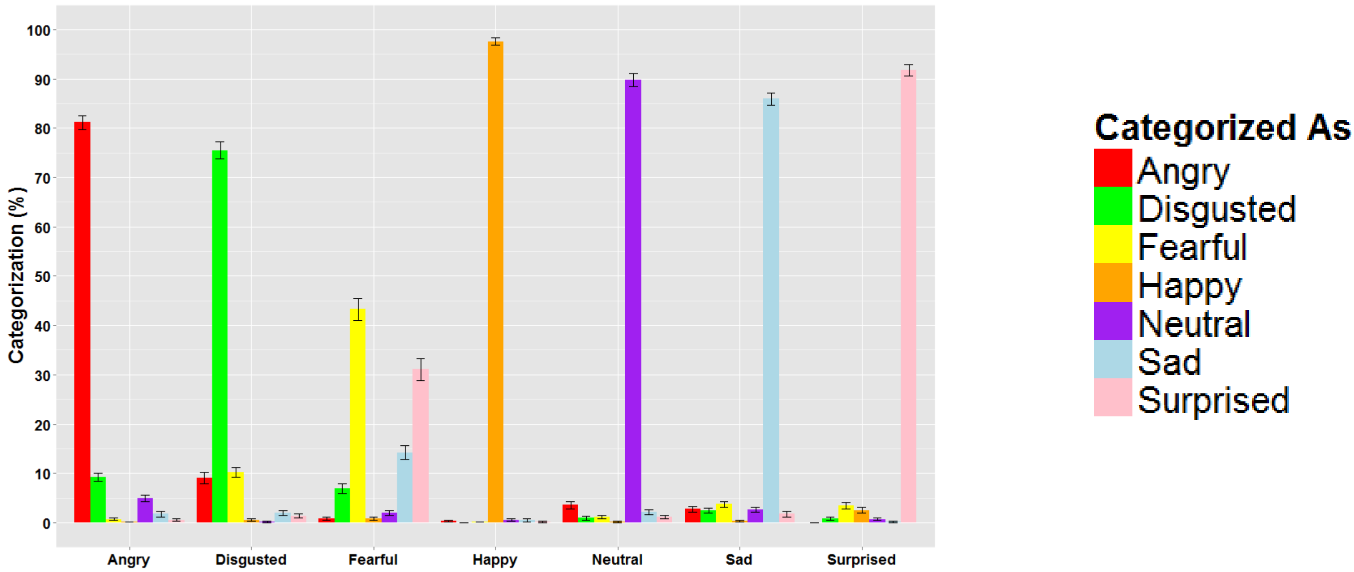

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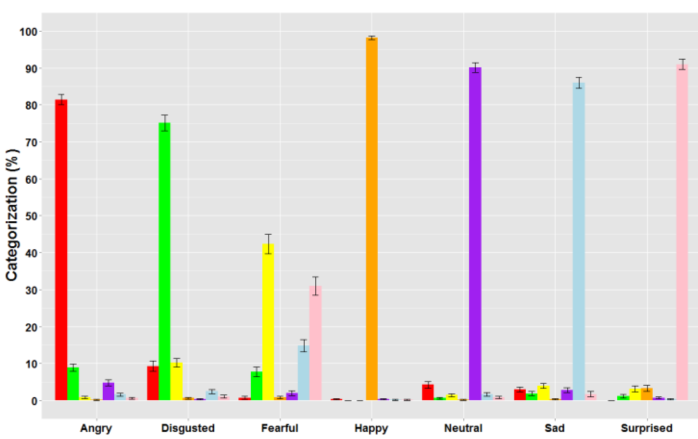

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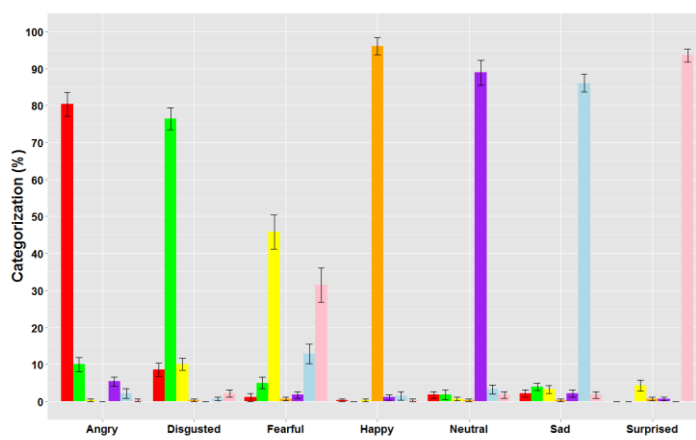

Bodily Expression Categorization Percentages

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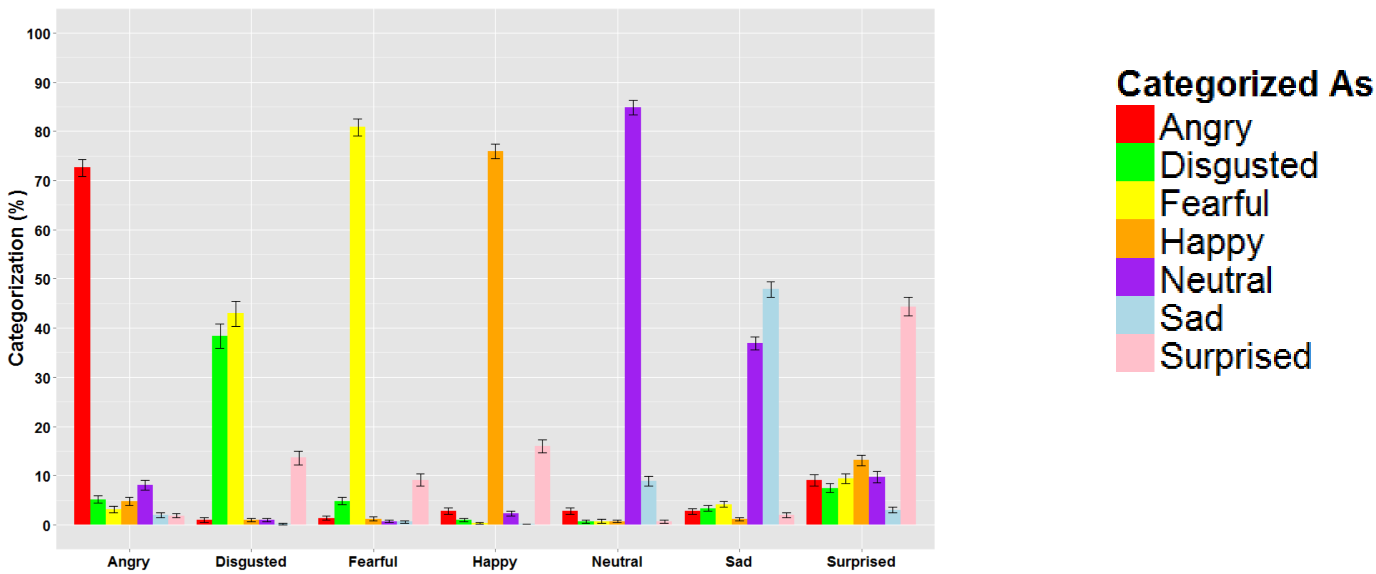

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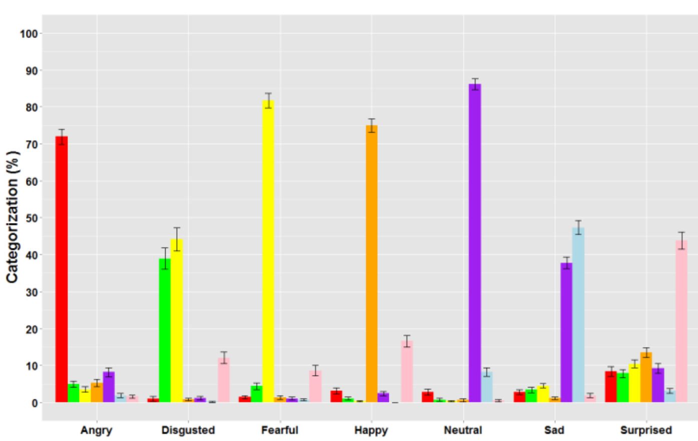

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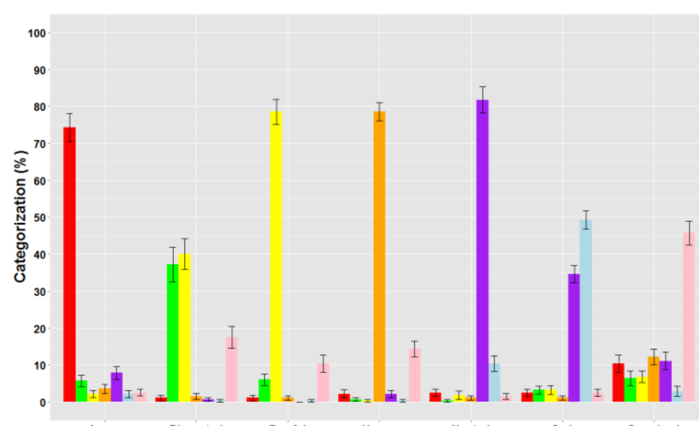

Categorization Percentages for Angry Facial Expressions across Contexts

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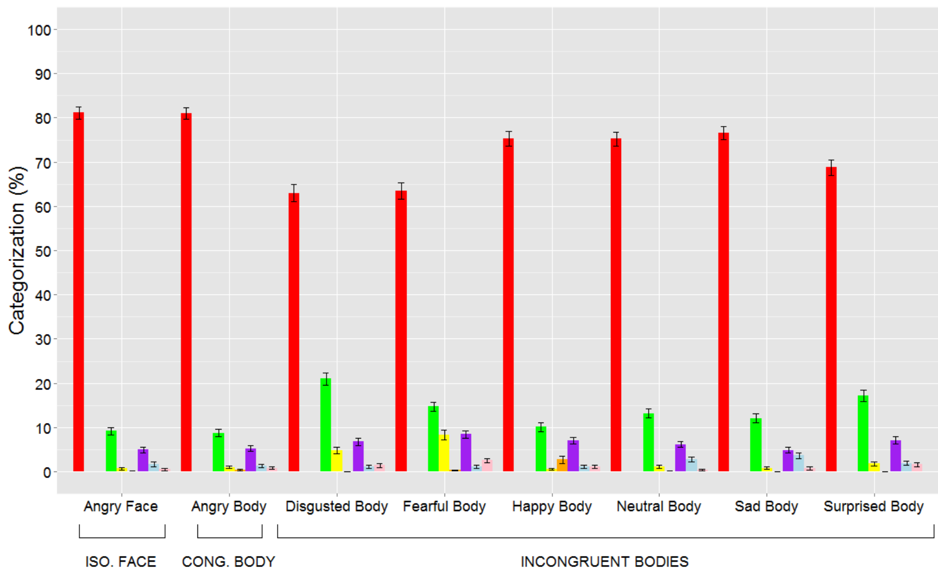

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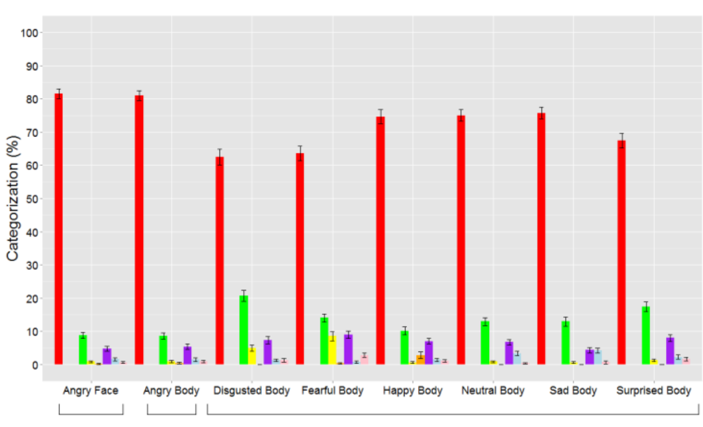

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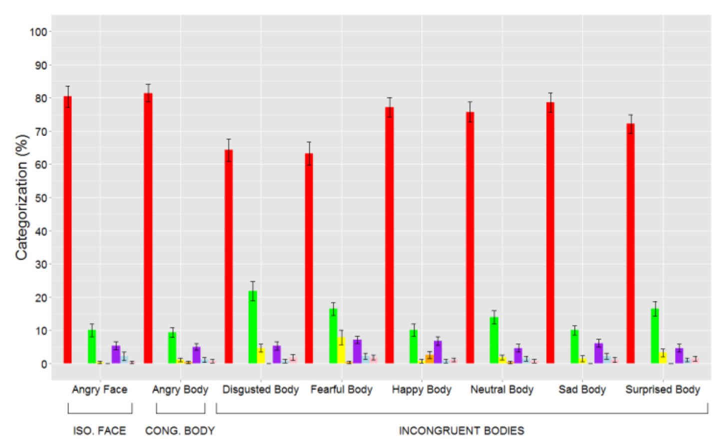

Categorization Percentages for Disgusted Facial Expressions across Contexts

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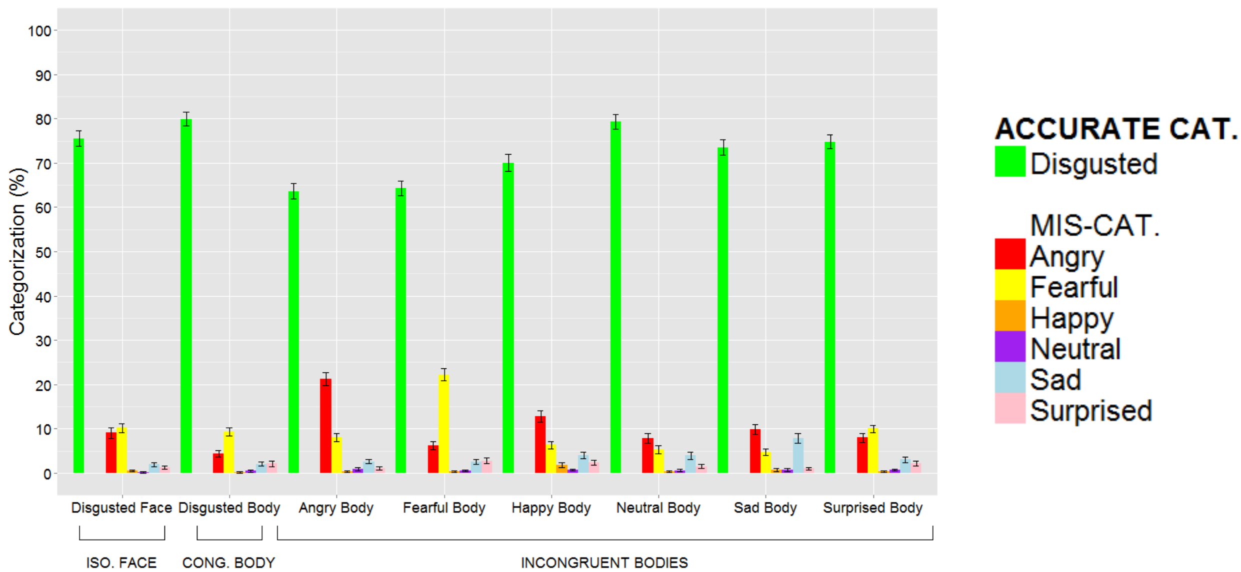
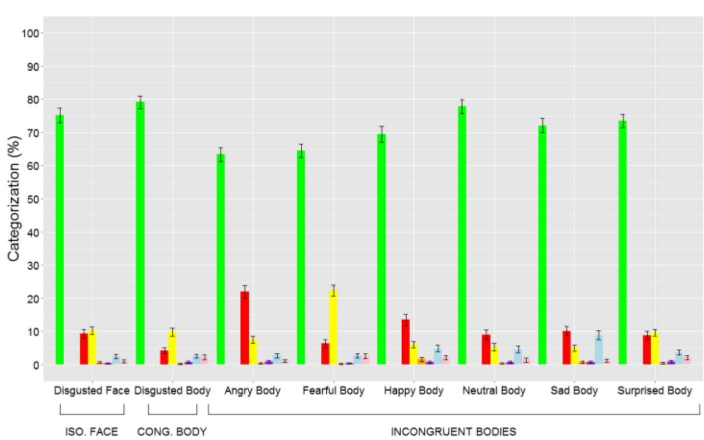
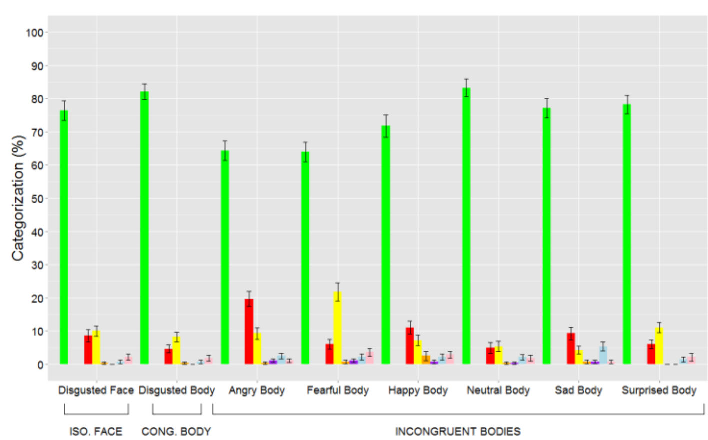


First Study (n=89)

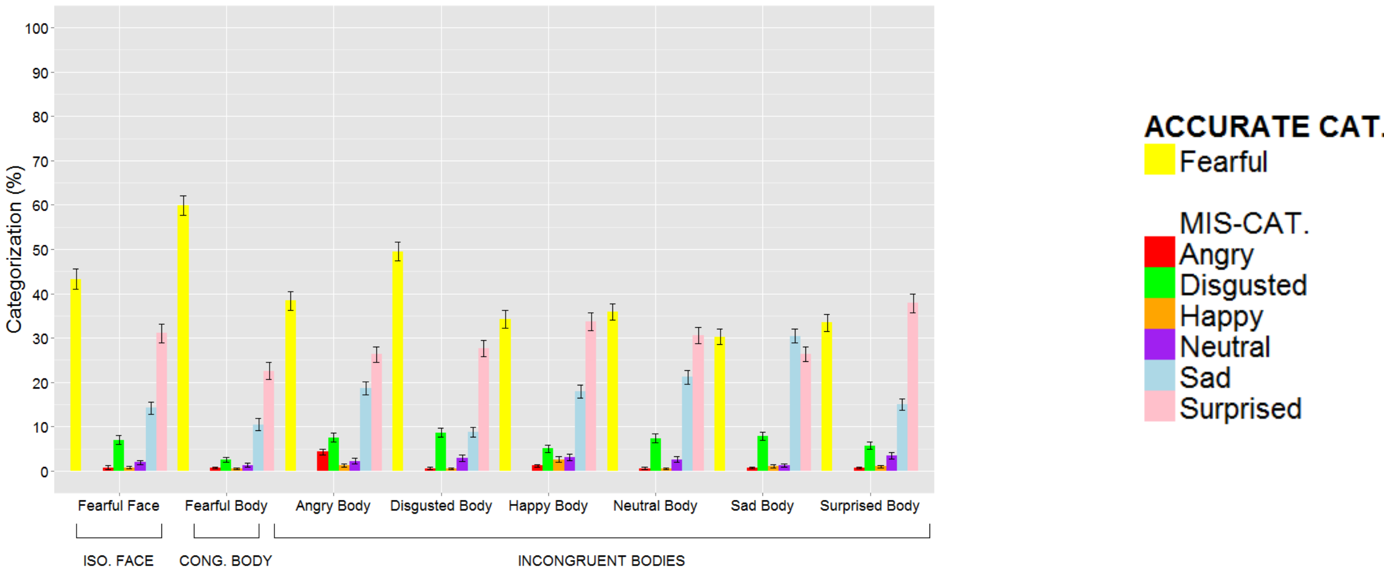
Second Study (n=35)



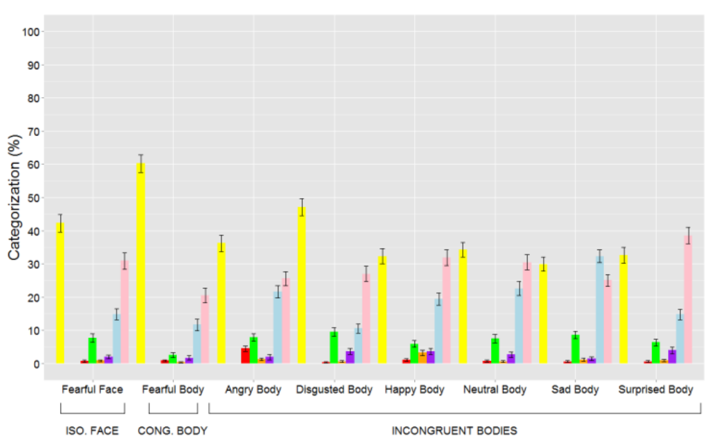


Categorization Percentages for Fearful Facial Expressions across Contexts

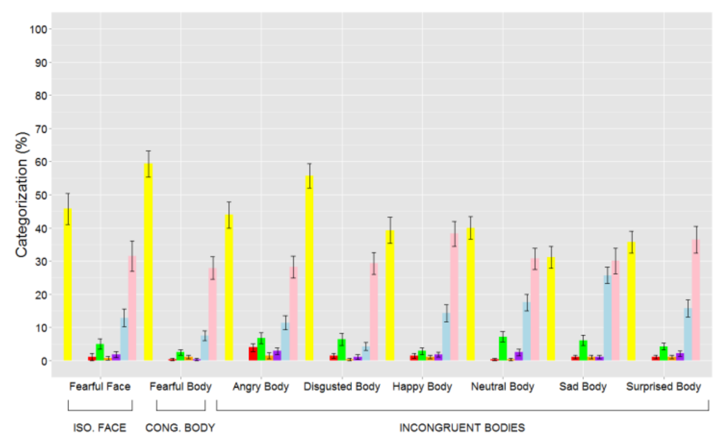
All Studies (n=124)



First Study (n=89)

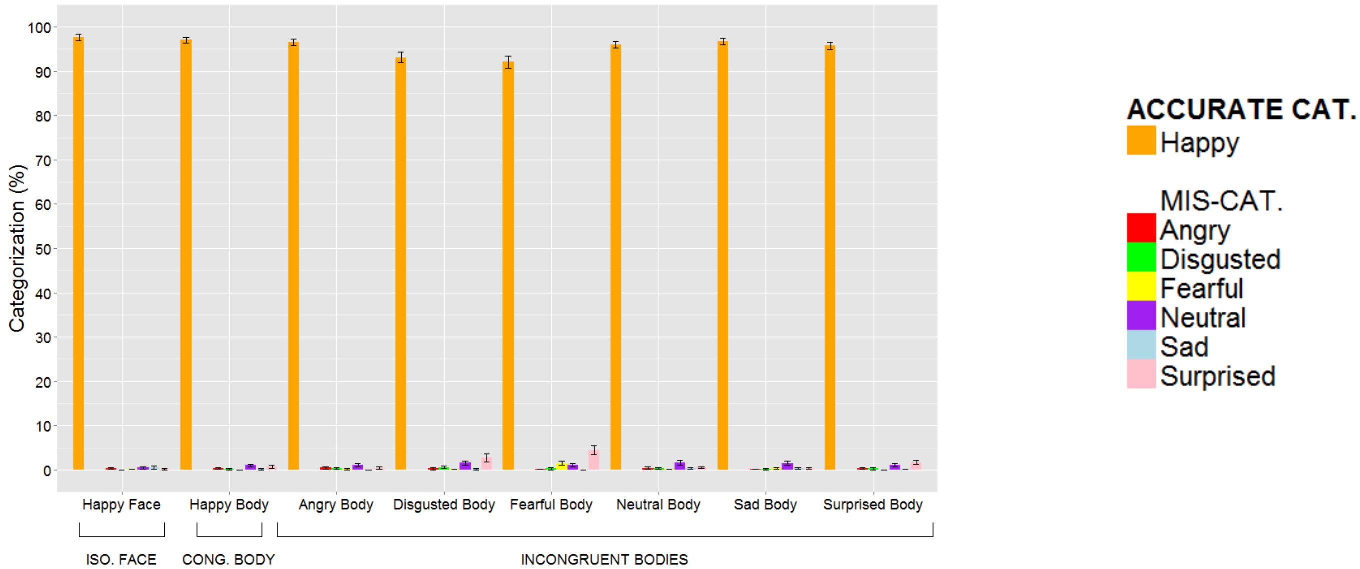


Second Study (n=35)

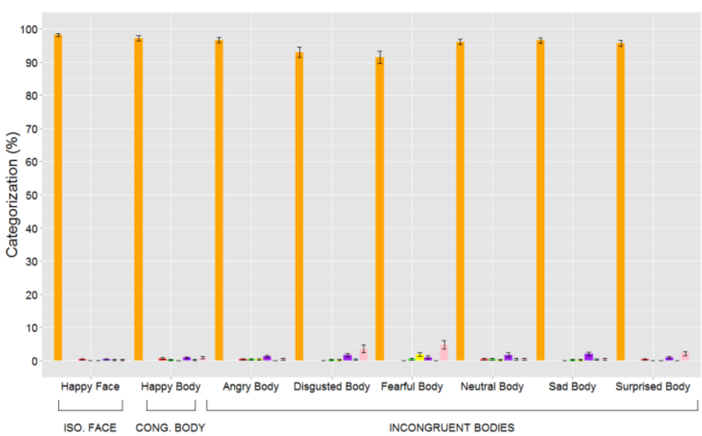


Categorization Percentages for Happy Facial Expressions across Contexts

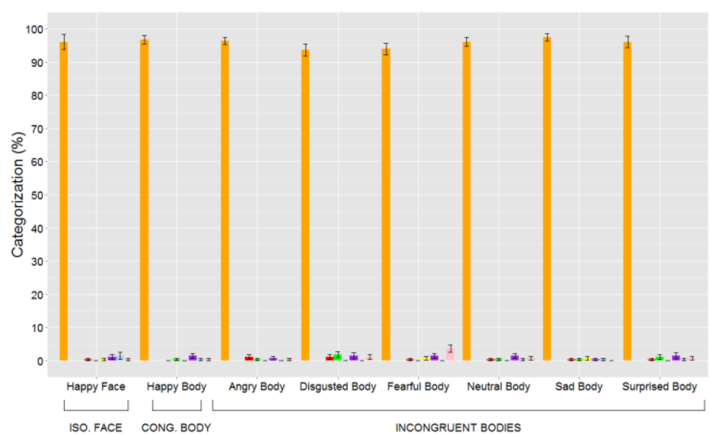
All Studies (n=124)



First Study (n=89)

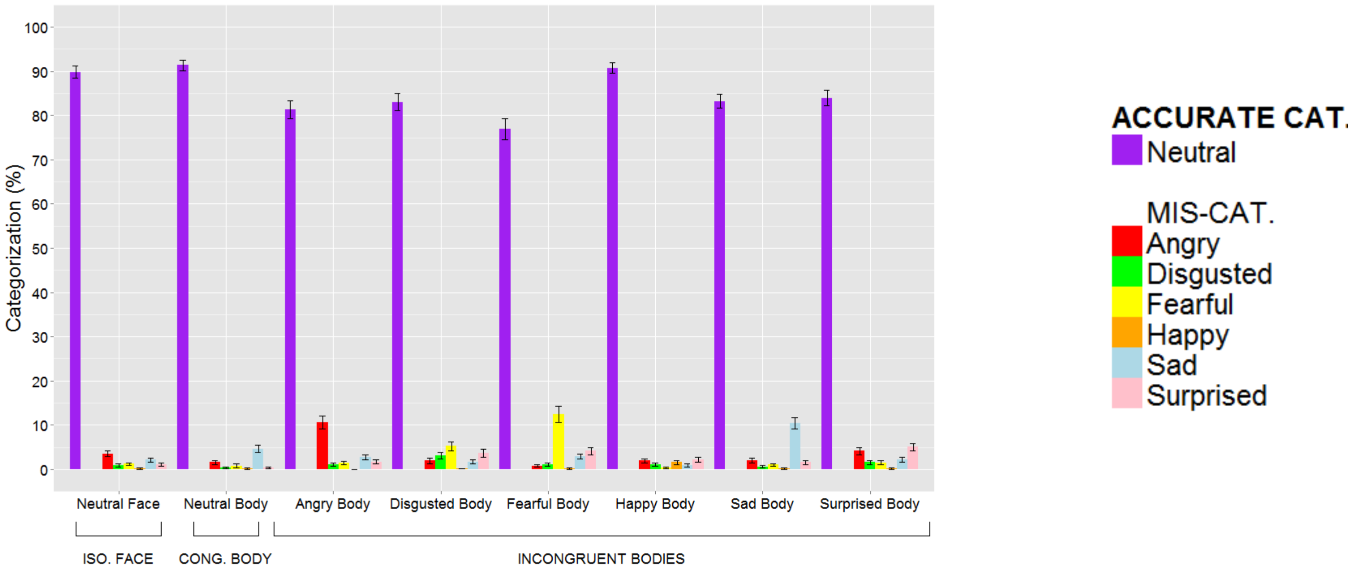


Second Study (n=35)

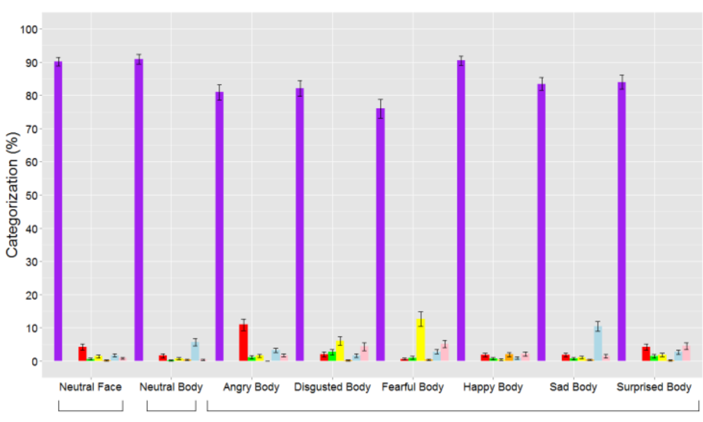


Categorization Percentages for Neutral Facial Expressions across Contexts

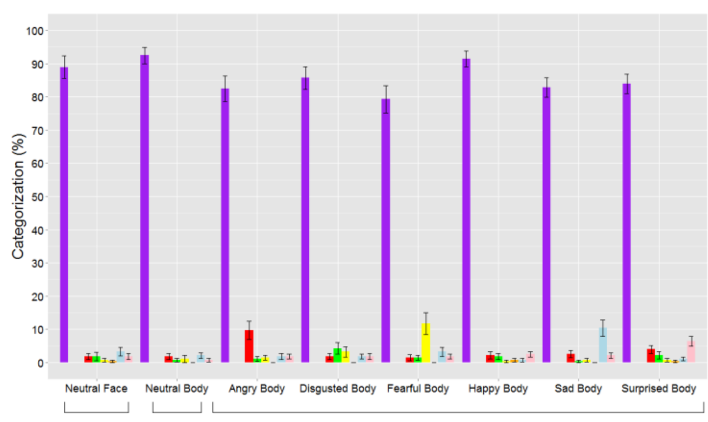
All Studies (n=124)



First Study (n=89)

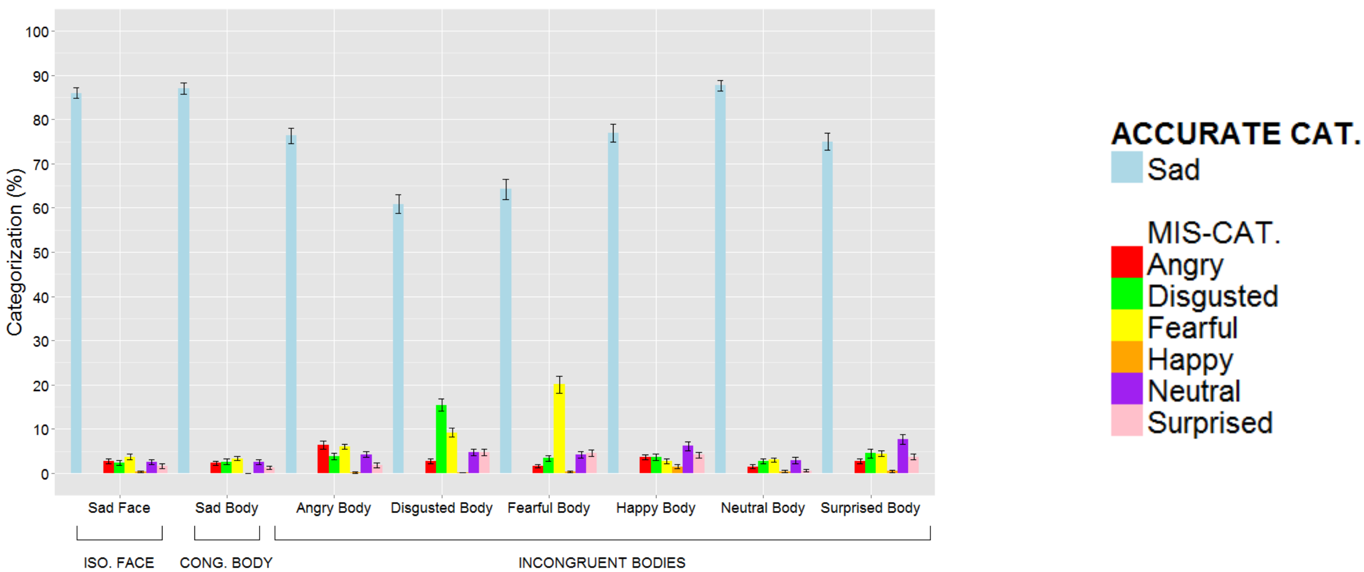


Second Study (n=35)

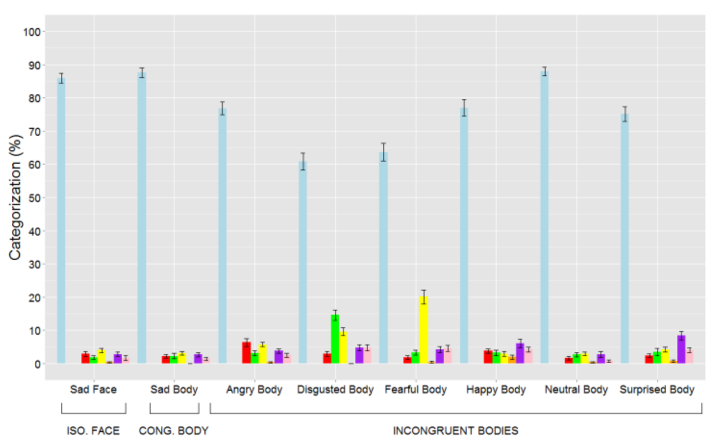


Categorization Percentages for Sad Facial Expressions across Contexts

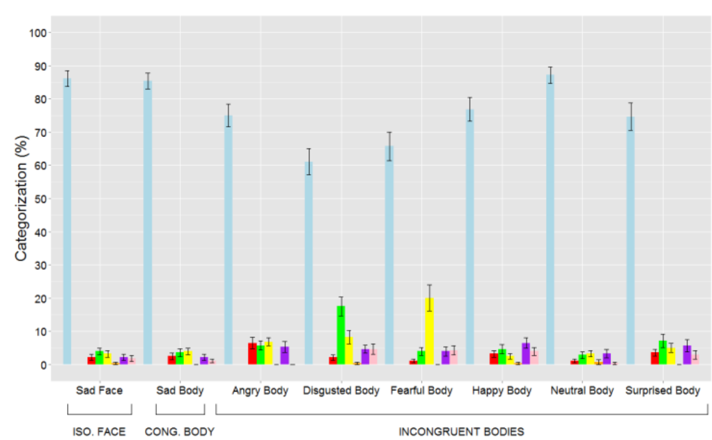
All Studies (n=124)



First Study (n=89)

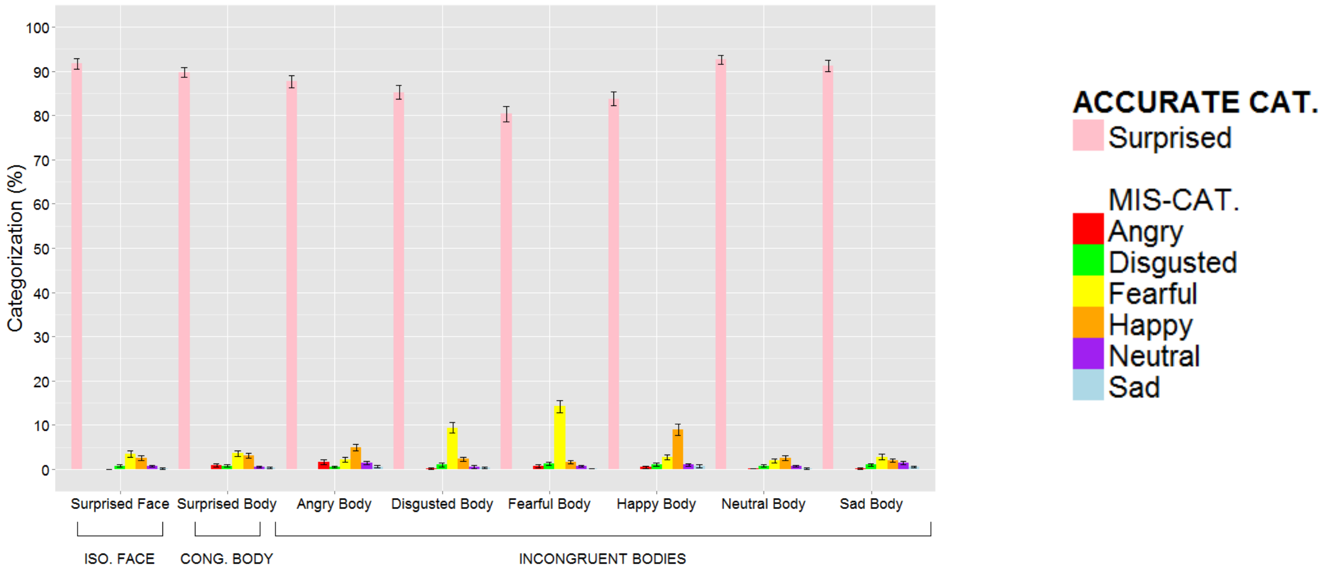


Second Study (n=35)

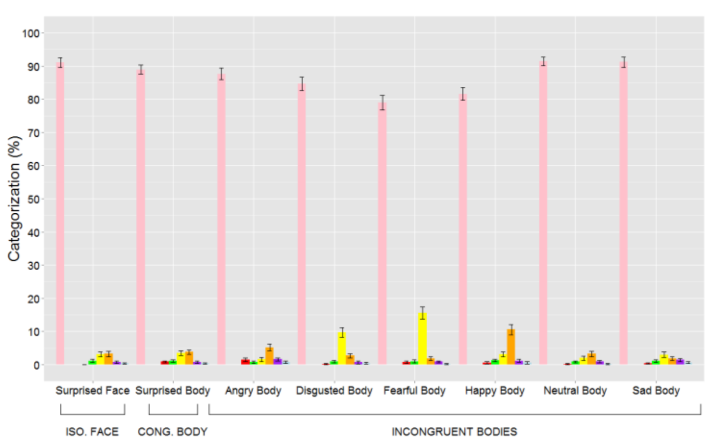


Categorization Percentages for Surprised Facial Expressions across Contexts

All Studies (n=124)



First Study (n=89)



Second Study (n=35)