COGNITION AND EMOTION, 2015
http://dx.doi.org/10.1080/02699931.2015.1070119

Routledge
Taylor & Francis Group

Perceptual dimensions differentiate emotions

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ABSTRACT
Individuals often describe objects in their world in terms of perceptual dimensions that span a variety of modalities; the visual (e.g., brightness: dark–bright), the auditory (e.g., loudness: quiet–loud), the gustatory (e.g., taste: sour–sweet), the tactile (e.g., hardness: soft vs. hard) and the kinaesthetic (e.g., speed: slow–fast). We ask whether individuals use perceptual dimensions to differentiate emotions from one another. Participants in two studies (one where respondents reported on abstract emotion concepts and a second where they reported on specific emotion episodes) rated the extent to which features anchoring 29 perceptual dimensions (e.g., temperature, texture and taste) are associated with 8 emotions (anger, fear, sadness, guilt, contentment, gratitude, pride and excitement). Results revealed that in both studies perceptual dimensions differentiate positive from negative emotions and high arousal from low arousal emotions. They also differentiate among emotions that are similar in arousal and valence (e.g., high arousal negative emotions such as anger and fear). Specific features that anchor particular perceptual dimensions (e.g., hot vs. cold) are also differentially associated with emotions.

ARTICLE HISTORY
Received 2 September 2014
Revised 29 June 2015
Accepted 30 June 2015

KEYWORDS
Emotions; perception; perceptual dimensions

Individuals often use perceptual features to characterise aspects of their world. For example, one's home might be described as being big, airy, bright, warm, colourful, roomy and square. Its exterior may be made of material that is heavy, thick, strong, hard and rough. The music inside may be harmonious and quiet. We use the term "perceptual features" to describe specific perceptual qualities that characterise entities. We use the term "perceptual dimensions" to describe the theoretical construct associated with opposing perceptual features. Thus big and small are perceptual features that anchor ends of a perceptual dimension of "size". Up and down are the end points of the perceptual dimension of "verticality". Notably, perceptual dimensions can also be used to characterise inanimate objects, places, and spaces as well as people. For example, warm & cold, hard & soft, loud & quiet, deep & shallow, bright & dark, sharp & dull, heavy & lightweight and sour & sweet are also used to characterise individuals' personalities (Asch, 1958). Two exploratory studies differing in emotion task (remember a specific emotion episode and report on it vs. think about and report on generalised emotion concepts) address a basic research question regarding whether perceptual dimensions also differentiate specific emotions.

Relevant research on perceptual dimensions

Research on language may provide the best support for the notion that perceptual dimensions might differentiate emotions, as researchers have linked the description and expression of emotion to metaphors and metonymies related to perceptual dimensions (e.g., Hoffman, Waggoner, & Palermo, 1991; Lakoff & Johnson, 1980; Ortony & Fainsilber, 1989). To illustrate, Lakoff and Johnson (1980) have noted a metaphorical relationship between anger and the perceptual dimension of temperature, with anger being characterised as "hot". Waggoner (2010) found that both children and adults agreed that love, hate and

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anger were described as "hot", whereas sorrow, fear and shame were described as "cold". McMullen and Conway (2002) observed that psychotherapy clients describing depression often used metaphors related to weight (I just feel so heavy), darkness (it's like a black cloud), constriction (I feel trapped) and verticality (I feel so low). To date, however, research has studied relatively few perceptual dimensions and their linkage with emotions.

Two additional literatures indirectly link emotions with specific perceptual dimensions, though these two research streams were not designed to address whether such dimensions differentiate specific emotions. One stream finds an association between perceptual dimensions and judgements of stimulus valence. For example, "up" is associated with positively valenced stimuli, whereas "down" is associated with negatively valenced stimuli (Crawford, Margolies, Drake, & Murphy, 2006; Meier & Robinson, 2004; Meier, Robinson, & Caven, 2008; Meier, Hauser, Robinson, Friesen, & Schjeldahl, 2007). Research in this stream also links "bright" with stimuli with positive meaning and "dark" with stimuli of negative meaning (e.g., Meier, Robinson, & Clore, 2004; Meier, Robinson, Crawford, & Ahlvers, 2007; Stabler & Johnson, 1972).

A second stream of research on embodied cognition shows that bodily states related to certain perceptual dimensions can *induce* emotions. For example, sitting "up" is associated with better performance on an achievement test than sitting in a slumped or "down" position (Stepper & Strack, 1993). Sitting "up" also induces more positive feelings than sitting in a slumped or "down" position (Riskind & Gotay, 1982). "Tight" vs. "loose" tension in the jaw or fist produced more (less) anger (Flack, 2006). To date, however, these research streams have typically studied a particular perceptual dimension (e.g., verticality) in isolation.

Whereas studies in these latter two research streams suggest that certain perceptual dimensions (1) are associated with generalised positive vs. negative feeling states and (2) might unconsciously *activate* emotions, we ask a different question: do individuals use perceptual dimensions (those described above *and others*) to *differentiate* specific emotions from one another? Below we describe two empirical studies that test this basic research question. We describe the perceptual dimensions and emotions we examined, and we describe two studies that aim to address our basic research question.

Study background

Perceptual dimensions studied in this research

In studying perceptual dimensions, we include (but expand upon) previously studied perceptual dimensions of temperature (cold vs. hot; e.g., Lakoff & Johnson, 1980; Waggoner, 2010), verticality (down vs. up; e.g., McMullen & Conway, 2002; Meier & Robinson, 2004; Stepper & Strack, 1993), brightness (dark vs. bright; e.g., McMullen & Conway, 2002; Meier et al., 2007), weight (lightweight vs. heavy; McMullen & Conway, 2002) and constriction (loose vs. tight; e.g., Flack, 2006).

Based on an analysis of common expressions of emotions we also include perceptual dimensions that might correspond with various metaphorical expressions of emotions, even if these features have not been the topic of prior research. Specifically, one might say that one "surrenders" to certain emotions, suggesting the perceptual dimension of strength (weak vs. strong). When angry, people may be said to have a "sharp" tongue; sadness is said to "dull" the senses, suggesting the perceptual dimension of sharpness (dull vs. sharp). The fact that sometimes one "can't let go" of certain emotions suggests a certain degree of stickiness. Going through a "rough patch" when one is experiencing negative emotions or "smooth sailing" when one is feeling positive ones suggests a perceptual dimension of texture (rough vs. smooth). When feeling content, one may feel fulfilled, suggesting a perceptual dimension of satiety (full vs. hungry). When sad, one may be said to be in the "depths of despair", suggesting a perceptual dimension of depth (shallow vs. deep). Certain negative feelings give one a "hard" time, suggesting the perceptual dimension of hardness (hard vs. soft). When feeling good, one is said to be on "solid" ground, suggesting the perceptual dimension of solidity (solid vs. fluid). One might use the phrase "sweet!" to describe good things, whereas anger is said to evoke a "sour" mood suggesting the perceptual dimension of sweetness (sweet vs. sour).

We also included perceptual dimensions that span a *range of perceptual modalities*; that is, what we see, hear, feel, taste and how things move, even if they are not observed in metaphorical expressions of emotions. By examining perceptual dimensions in each of the sensory modalities (i.e., vision, hearing, taste, smell, etc.), we explicitly consider and empirically examine whether the perceptual modalities are

redundant with one another. Moreover, evidence that emotions are differentiated in terms of multiple perceptual modalities would provide stronger support for the idea that perceptual dimensions differentiate emotions. It would also augment and extend prior research by linking emotions with perceptual dimensions in unexamined modalities. For example, whereas anger may be differentiated from emotions like fear in terms of temperature (anger is hot; Lakoff & Johnson, 1980), we currently lack knowledge of whether anger is also differentiated from fear in other sensory modalities (e.g., vision, hearing and taste).

Based on these criteria, and related to the visual modality, we included the perceptual dimension of breadth (narrow vs. broad); colour (black and white vs. coloured); position (inside vs. outside); openness (closed vs. open); spaciousness (crowded vs. roomy); shape (square vs. round); curvature (wavy vs. straight) and thickness (thin vs. thick). We included other perceptual dimensions that reflect the auditory modality, specifically, harmony (discordant vs. harmonious) and decibel level (quiet vs. loud). In addition, we included dimensions that reflect the tactile modality, such as texture (rough vs. smooth). Finally, we included dimensions that represent the kinaesthetic modality including speed (slow vs. fast).

The full set of perceptual dimensions and their associated perceptual features are shown in the second and third columns of Tables 1 and 2. We do not assume that these dimensions represent an exhaustive set. To the extent that we have undersampled perceptual dimensions, we have created a more conservative test of the question of whether perceptual dimensions differentiate emotions.

Emotions studied in this research

Our two empirical studies examined eight emotions: anger, guilt, fear, sadness, contentment, gratitude, excitement and pride. To the extent that we have undersampled emotions, it should be more difficult for us to find evidence that perceptual dimensions differentiate emotions. Our aim was to sample a set of commonly studied emotions that vary in *valence* and *arousal*—two primitive aspects of emotion that have received considerable attention in past research and have been previously found to differentiate emotions (Feldman Barrett, 1998; Russell & Mehrabian, 1977). Since our primary research question asks whether perceptual dimensions differentiate emotions, it is important to determine whether perceptual dimensions map with and/or go beyond arousal and valence in differentiating emotions.

Anger and fear were selected as negatively valenced, high arousal emotions; sadness and guilt were selected as negatively valenced, low arousal emotions; excitement and pride were selected as positively valenced, high arousal emotions, and contentment and gratitude were selected as positively valenced, low arousal emotions. In this way, the specific emotions we study represent the emotional space commonly linked with emotions (Figure 1). Our goal was to determine whether perceptual dimensions differentiate positive from negative emotions, high arousal from low arousal emotions, and emotions that occupy the same space in the valence/arousal framework.[1]

Methods: studies A and B

Data were collected for two studies. Each provided participants with the set of perceptual features shown in Tables 1 and 2 (see column 3) and asked the extent to which the perceptual features characterise the emotion(s) in question (Figure 1). The studies differed significantly in the emotion task. Study A, the "emotion concept study", aimed to activate generalised emotion concepts. Respondents were asked to merely indicate which perceptual features are associated with each emotion without asking them to elaborate or re-experience a particular emotion episode in any depth. Study B, the "experienced emotions" study, asked respondents to write in detail about a specific, concrete emotion episode they had experienced in the past and to write about and re-experience that particular emotion episode in detail. They were then asked to rate the extent to which each perceptual feature characterised that emotional experience. We describe details of each study next.

Study A: emotion concept study

Participants and design

Fifty-three paid participants (53.4% male) between the ages of 18 and 27 ($M = 21.7$, $SD = 2.1$) completed

[1]We had originally included envy as an additional emotion in Study A, however, it was not clear whether envy reflected a high or a low arousal negative emotion, nor whether envy was generally regarded as negatively valenced by respondents; provided this ambiguity and our basic focus on whether perceptual dimensions differentiate among emotions of similar levels of arousal and valence, envy was dropped.

Table 1. Logit model results for study A: emotion concepts.

	Perceptual dimension	Scale anchors	Model 1: Positive (1) vs. negative (0) emotions ($N = 53$)		Model 2: High arousal (1) vs. low arousal (0) emotions ($N = 53$)		Model 3: Positive high arousal emotions: excitement (1) vs. pride (0) ($N = 53$)		Model 4: Positive low arousal emotions: contentment (1) vs. gratitude (0) ($N = 53$)		Model 5: Negative high arousal emotions: anger (1) vs. fear (0) ($N = 53$)		Model 6: Negative low arousal emotions: sadness (1) and guilt (0) ($N = 53$)	
			Coeff.	$P > z$	Coeff.	$P > z$	Coeff.	$P > z$	Coeff.	$P > z$	Coeff.	$P > z$	Coeff.	$P > z$
Gustatory	Taste	sour–sweet	**1.293**	**0.007**	0.031	0.904	0.336	0.776	−1.513	0.092	0.425	0.670	**2.821**	**0.020**
	Satiety	hungry–full	0.251	0.457	−0.267	0.128	−1.639	0.244	**1.578**	**0.011**	−1.839	0.169	−0.359	0.584
Visual	Solidity	fluid–solid	0.152	0.656	−0.075	0.624	−0.205	0.811	0.332	0.364	**1.814**	**0.053**	0.007	0.990
	Brightness	dark–bright	**1.895**	**0.001**	−0.296	0.238	0.239	0.898	**−1.981**	**0.029**	0.474	0.535	−1.749	0.123
	Spaciousness	crowded–roomy	0.331	0.396	0.130	0.487	−0.988	0.386	0.701	0.264	**−4.034**	**0.032**	0.358	0.592
	Colour	black & white—multicoloured	0.145	0.691	0.062	0.723	**−4.992**	**0.027**	**1.715**	**0.007**	−3.814	0.055	0.161	0.816
	Breadth	narrow–broad	0.864	0.076	0.092	0.645	1.771	0.177	1.003	0.111	0.491	0.561	−0.449	0.511
	Position	inside–outside	−0.188	0.621	0.104	0.494	1.077	0.248	−0.604	0.078	−1.361	0.211	**1.754**	**0.013**
	Openness	closed–open	**1.040**	**0.024**	−0.280	0.168	**7.559**	**0.003**	0.586	0.278	0.040	0.973	−0.034	0.962
	Shape	square–round	**−0.804**	**0.042**	−0.267	0.149	2.420	0.077	−0.223	0.666	1.123	0.224	−0.991	0.108
	Curvature	wavy–straight	0.435	0.269	0.250	0.120	**−4.118**	**0.005**	0.516	0.169	**−3.867**	**0.047**	−0.932	0.178
	Thickness	thin–thick	**0.785**	**0.024**	**−0.329**	**0.039**	**−3.850**	**0.009**	−0.355	0.317	−0.651	0.354	1.318	0.101
	Size	small–big	−0.330	0.377	−0.056	0.761	**−5.182**	**0.031**	−0.785	0.219	1.337	0.303	0.492	0.487
	Clarity	cloudy–clear	0.583	0.148	−0.164	0.451	**−5.034**	**0.023**	−0.326	0.625	−1.578	0.127	−0.767	0.357
	Depth	shallow–deep	−0.804	0.056	−0.296	0.068	0.476	0.494	−0.737	0.144	−0.273	0.667	**1.444**	**0.029**
	Expansiveness	contractive–expansive	0.096	0.829	−0.201	0.319	0.246	0.852	−0.634	0.309	**4.613**	**0.021**	**1.938**	**0.016**
Kinaesthetic	Speed	slow–fast	0.042	0.916	**0.660**	**0.000**	**4.332**	**0.021**	−0.288	0.492	1.098	0.172	**−1.921**	**0.024**
	Verticality	down–up	−0.144	0.731	**0.520**	**0.027**	2.105	0.204	−0.779	0.187	0.596	0.561	**−2.091**	**0.039**
Tactile	Stickiness	non-sticky–sticky	−0.615	0.132	−0.167	0.338	0.181	0.896	−0.694	0.195	**−4.762**	**0.044**	−0.194	0.755
	Constriction	loose–tight	−0.289	0.495	−0.014	0.936	−3.056	0.058	0.374	0.387	0.950	0.303	−0.385	0.615
	Sharpness	dull–sharp	−0.194	0.616	**0.378**	**0.022**	**−2.522**	**0.021**	−0.225	0.604	−3.524	0.059	−0.960	0.079
	Pressure	weak–strong	**1.119**	**0.010**	0.209	0.263	0.612	0.642	0.511	0.376	**4.196**	**0.024**	−0.911	0.231
	Temperature	cold–hot	−0.160	0.670	**0.448**	**0.005**	1.537	0.177	−0.814	0.064	**4.725**	**0.045**	**−0.834**	**0.093**
	Density	airy–dense	−0.579	0.161	0.140	0.442	0.376	0.687	−0.069	0.860	−2.352	0.166	**−1.724**	**0.038**
	Texture	rough–smooth	**1.533**	**0.002**	−0.184	0.380	2.113	0.114	**1.424**	**0.021**	−0.432	0.795	0.837	0.232
	Softness	hard–soft	−0.478	0.260	**−0.576**	**0.003**	−1.372	0.073	−1.075	0.055	3.105	0.154	−0.025	0.973
	Weight	lightweight–heavy	−0.608	0.131	**−0.529**	**0.008**	0.145	0.907	−0.997	0.056	−3.379	0.119	−0.642	0.386
Auditory	Decible level	quiet–loud	0.171	0.701	**0.776**	**0.000**	1.813	0.069	0.236	0.569	**4.141**	**0.020**	−0.240	0.748
	Harmony	discordant–harmonious	−0.336	0.481	−0.194	0.393	**3.679**	**0.045**	0.529	0.396	0.397	0.632	0.668	0.478
	Constant		−0.527	0.060	0.109	0.395	−5.106	0.005	−0.841	0.187	−0.501	0.543	−1.775	0.027
		Measure of fit (McFadden's R^2)	0.76		0.32		0.74		0.34		0.66		0.57	
	LR test		448.573***		190.38***		109.38***		50.21**		97.9***		84.19***	

Note: The bold values refer to those cases where the coefficient is significant ($p < .05$).
***Model significance $p < .001$.
**Model significance $p < .01$.

Table 2. Logit model results for study B: Experienced emotion episodes.

	Perceptual dimension	Scale anchors	Model 7: Positive (1) vs. negative (0) emotions (*N* = 745)		Model 8: High arousal (1) vs. low arousal (0) emotions (*N* = 745)		Model 9: Positive high arousal emotions: excitement (1) vs. pride (0) (*N* = 188)		Model 10: Positive low arousal emotions: contentment (1) vs. gratitude (0) (*N* = 193)		Model 11: Negative high arousal emotions: anger (1) vs. fear (0) (*N* = 174)		Model 12: Negative low arousal emotions: sadness (1) and guilt (0) (*N* = 190)	
			Coeff.	*P* > z	Coeff.	*P* > z	Coeff.	*P* > z	Coeff.	*P* > z	Coeff.	*P* > z	Coeff.	*P* > z
Gustatory	Taste	sour–sweet	**3.453**	**0.000**	0.131	0.495	−0.424	0.416	0.091	0.839	**−1.407**	**0.023**	0.229	0.586
	Satiety	hungry–full	0.273	0.439	**−0.342**	**0.003**	0.034	0.901	−0.027	0.916	0.528	0.106	−0.055	0.835
Visual	Solidity	fluid–solid	**0.906**	**0.014**	−0.123	0.231	−0.442	0.086	−0.318	0.125	0.084	0.790	−0.006	0.983
	Brightness	dark–bright	**1.209**	**0.046**	0.229	0.277	−0.240	0.629	−0.465	0.255	0.894	0.108	−0.989	0.083
	Spaciousness	crowded–roomy	0.326	0.516	−0.225	0.086	−0.321	0.248	−0.056	0.844	**1.455**	**0.002**	−0.055	0.869
	Colour	black &white—multicoloured	0.062	0.897	0.052	0.655	**−0.765**	**0.024**	−0.379	0.176	0.347	0.315	−0.131	0.603
	Breadth	narrow–broad	0.243	0.636	0.177	0.151	0.070	0.816	−0.196	0.488	0.175	0.607	−0.244	0.381
	Position	inside–outside	−0.126	0.756	−0.170	0.100	0.115	0.574	−0.103	0.609	−0.059	0.855	0.012	0.965
	Openness	closed–open	0.087	0.892	−0.194	0.239	−0.001	0.998	0.413	0.276	−0.277	0.537	0.498	0.155
	Shape	square–round	0.067	0.879	−0.094	0.412	**−0.646**	**0.023**	−0.282	0.216	0.136	0.645	0.398	0.193
	Curvature	wavy–straight	−0.691	0.085	−0.120	0.256	−0.391	0.103	0.126	0.563	**0.821**	**0.025**	0.156	0.541
	Thickness	thin–thick	−0.318	0.569	−0.178	0.122	0.376	0.203	−0.065	0.810	0.620	0.116	0.159	0.554
	Size	small–big	**0.964**	**0.048**	0.069	0.572	**−0.841**	**0.053**	−0.459	0.074	−0.639	0.112	0.084	0.733
	Clarity	cloudy–clear	0.149	0.749	0.153	0.270	−0.092	0.846	−0.372	0.329	0.003	0.995	0.323	0.245
	Depth	shallow–deep	**−0.815**	**0.039**	**−0.271**	**0.014**	**−0.773**	**0.008**	0.084	0.741	**−0.766**	**0.018**	**0.874**	**0.000**
	Expansiveness	contractive–expansive	0.055	0.915	−0.147	0.273	0.007	0.984	−0.073	0.812	0.070	0.854	0.099	0.727
Kinaesthetic	Speed	slow–fast	0.559	0.174	**0.594**	**0.000**	**0.795**	**0.010**	−0.039	0.877	−0.045	0.889	−0.441	0.086
	Verticality	down–up	**1.558**	**0.026**	**0.385**	**0.019**	0.301	0.491	−0.136	0.696	0.006	0.988	−0.188	0.613
Tactile	Stickiness	non-sticky–sticky	−0.101	0.767	**−0.307**	**0.004**	−0.268	0.289	**−0.430**	**0.053**	0.292	0.380	−0.405	0.121
	Constriction	loose–tight	−0.441	0.344	0.247	0.062	0.131	0.648	**−0.660**	**0.010**	−0.054	0.903	0.004	0.991
	Sharpness	dull–sharp	−0.728	0.100	0.197	0.073	0.137	0.686	−0.079	0.777	−0.060	0.860	−0.084	0.677
	Pressure	weak–strong	−0.638	0.124	**−0.376**	**0.005**	0.083	0.844	−0.100	0.799	−0.575	0.096	0.339	0.169
	Temperature	cold–hot	0.309	0.428	**0.389**	**0.000**	**0.790**	**0.026**	−0.134	0.665	**1.567**	**0.000**	−0.244	0.281
	Density	airy–dense	0.572	0.339	−0.148	0.299	**−0.685**	**0.024**	−0.152	0.564	−0.218	0.681	**−1.025**	**0.013**
	Texture	rough–smooth	0.422	0.442	**−0.561**	**0.001**	0.264	0.537	0.336	0.337	0.545	0.374	**−0.866**	**0.038**
	Softness	hard–soft	0.554	0.361	**−0.512**	**0.002**	0.425	0.231	−0.504	0.150	**−1.462**	**0.040**	0.438	0.258
	Weight	lightweight–heavy	**−1.819**	**0.001**	**−0.378**	**0.031**	−0.137	0.690	−0.504	0.102	−0.344	0.562	0.746	0.260
Auditory	Decible Level	quiet–loud	−0.565	0.277	**0.450**	**0.000**	0.230	0.392	−0.015	0.955	−0.152	0.678	**−0.799**	**0.001**
	Harmony	discordant–harmonious	0.381	0.575	−0.026	0.869	0.182	0.644	0.376	0.269	−0.601	0.187	−0.273	0.452
	Constant		0.733	0.058	−0.068	0.451	−0.933	0.054	−0.646	0.133	−0.665	0.208	−1.068	0.053
	Measure of fit (McFadden's R^2)		0.884		0.279		0.344		0.216		0.514		0.356	
LR test			923.27***		298.87***		91.12***		60.55***		126.73***		97.82***	

Note: The bold values refer to those cases where the coefficient is significant ($p < .05$).
***Model significance $p < .001$.
**Model significance $p < .01$.

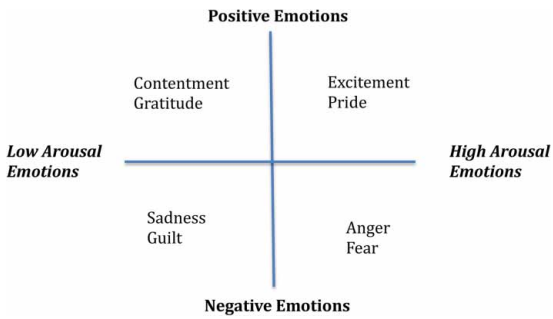

Figure 1. Emotions studied.

Study A at a campus behavioural lab. This study used a one-way design with eight *within-subjects emotion conditions*. The emotions studied were anger, fear, guilt, sadness, excitement, pride, gratitude and contentment (as shown in Figure 1). This within-subjects design has the advantage of controlling for individual differences that might otherwise create variation across the various emotion conditions. Since respondents rated each of the 8 emotions on each of the 58 perceptual features shown in column 3 of Table 1, this design also encourages the activation of more readily available emotion concepts and discourages deep elaboration and re-activation of particular emotional episodes.

Procedures

Participants were told that they would be completing a study about "how you experience emotion". They were told that they would be asked to consider a set of different emotions and to answer a set of questions about each emotion. Specifically, they would be asked the extent to which a series of words describe their experience of that particular emotion. Before beginning, participants were guided through an illustrative example shown in Appendix A. The example asked participants to imagine the emotion of amusement and to consider what amusement feels like. With this feeling in mind, they were asked to indicate the extent to which a set of words describes that emotion. Participants were provided with a small subset of the perceptual features they would ultimately rate and were shown an example of how a hypothetical respondent might rate amusement in terms of these features.

After indicating they understood the task, participants proceeded to the focal emotions task. They were asked to imagine a situation when they felt the target emotion and to consider what the target emotion feels like. For each emotion, participants used a slider to rate the features on a 101 point scale, where 0 = not at all and 100 = very much to indicate the extent to which the 58 perceptual features characterise that emotion. Respondents rated all the perceptual features associated with one emotion (e.g., anger) before rating the features associated with a second emotion. Each respondent completed the rating process for each of the eight emotions. The presentation order of the emotions was randomised for each individual.

Several aspects of the study's procedure are noteworthy. First, respondents were not asked to think deeply about the emotion or the perceptual feature-emotion correspondence, nor were they asked to relive or retell a particular autobiographical episode in which they had experienced that emotion; hence elaboration of the emotion episode was relatively low. Since respondents were merely asked to imagine an emotion (e.g., anger), the associations they made between the specific perceptual features on the one hand and the emotions on the other likely reflect relatively automatic associations. This emotion concept context might provide a conservative test of the metaphorical relationship between perceptual features and emotions, since metaphorical reasoning generally involves some degree of elaborative processing (Panther, 2005) that may not be activated when respondents consider emotion concepts. Specifically, by asking respondents to simply imagine an emotion (absent having them verbalise or articulate a particular episode) prior to describing its perceptual features, it seems less likely that a given perceptual dimension would systematically correspond with a particular emotion; hence, this approach provides a relatively conservative test of our basic research question.

Study B: emotion experience study

Participants and design

Seven hundred forty five individuals (49% male) between the ages of 18 and 61 ($M = 28.08$, SD *5.23*) completed Study B as part of an online study using Amazon's Mechanical Turk. Participants were paid $1.25 as compensation for participation. The study used a one-way design with eight *between-subject* emotion conditions. While this between-subjects design does not control for variation across respondents and emotion conditions as did the within-subjects design in Study A, it does reduce the likelihood

of respondent fatigue and avoid possible carry-over effects of one emotional experience on another (i.e., re-experiencing anger may affect the subsequent re-experiencing of contentment). Such carry-over effects are also unlikely in Study A because respondents reported on emotion concepts (i.e., they were not asked to vividly relive an emotional experience) and the order of emotions was randomised.

Procedures

Before introducing the focal emotion task, participants were shown the same illustrative example shown to participants in Study A (see Appendix A). After reviewing the example, participants were randomly assigned to one of the eight emotion conditions. Study B used the same eight focal emotions as those in Study A. However, in Study B, participants in each condition were asked to recall and write about a time when they had personally experienced one focal emotion and to complete two open-ended questions as truthfully and in as much detail as possible about it. This emotion induction procedure is a relatively standard method for *inducing* emotional states (see Lench, Flores, & Bench, 2011). The open-ended questions asked participants to: (1) "Briefly describe three to five things that make you most ____." (2) "Please describe in detail the one situation that makes you, or has made you, most ___. Write as detailed a description as possible. If you can, write your description so that someone reading it might even feel _____ just by reading what you describe." After writing about the focal emotion, participants were asked to indicate the extent to which the perceptual features shown in Table 1 describe that emotion. They used the same 101-point sliding scale used in Study A. We anticipated that the emotion evoked in Study B would be more concrete, vivid and evocative than was true in Study A since respondents were asked to recall a particular episode and elaborate on it. On the other hand, the specific emotion episodes are more idiosyncratic and person-situation dependent in Study B than in Study A. These idiosyncratic elements are likely to increase variability and make it more challenging to find systematic differences in perceptual dimensions differentiating specific emotions.

Measurement

Participants in both studies used the same 0–100 point scale to rate the extent to which the 58 perceptual features were associated with the emotion(s) in question. Thus, respondents evaluated the extent to which the emotion in question is "hot" (0 = not at all; 100 = very much). A second item asked them to rate the extent to which it is "cold" (0 = not at all; 100 = very much). We converted these 58 perceptual features (hot, cold, deep and shallow) into 29 perceptual dimensions (e.g., temperature and depth) by taking the difference between the ratings of the two perceptual features that anchor a specific perceptual dimension. To illustrate, participants were asked to rate the extent to which "hot" describes anger. They were also asked the extent to which "cold" describes anger. The temperature dimension for anger thus reflects the difference between the rating on hot and the rating on cold. The resulting measure for temperature could thus range from −100 (cold) to +100 (hot). This procedure allows us to ask (a) whether the perceptual dimensions differentiate among the emotions, and (b) if so, which features (hot or cold) are associated with a specific emotion relative to others. Because different perceptual dimensions might be conceptualised differently (i.e., that a one-point change in temperature may not be the same as a one-point change in decibel level), we standardised the data by centering each perceptual dimension around a mean equal to zero (0) with a standard deviation of one (1).

Emotions to be differentiated

Positive vs. negative

The basic research question of whether perceptual dimensions differentiate among emotions first requires that we specify which emotions are to be differentiated from others. Since prior research links certain positive emotions with certain dimensions like brightness we might expect that certain perceptual dimensions would be significant in differentiating positive from negative emotions. Moreover, we might expect that relative to negative emotions, positive emotions would be described as being higher on one end of the perceptual dimension than the other (e.g., positive emotions would be more likely to be described as bright than dark). Hence, we asked whether these perceptual dimensions differentiate positive from negative emotions.

High arousal vs. low arousal

Second, since prior research links certain high arousal emotions with certain perceptual dimensions like speed, we might expect that certain perceptual

dimensions would be significant in differentiating high arousal emotions (here anger, fear, excitement and pride) from low arousal emotions (here sadness, guilt, contentment and gratitude; Figure 1). Moreover, based on past research, we might expect that relative to low arousal emotions, high arousal emotions would be described as being higher on one end of the perceptual dimension than another (e.g., more fast than slow). Hence, we asked whether these perceptual dimensions differentiate high arousal from low arousal emotions.

Valence by arousal

A simple, naive theory is that the perceptual dimensions, if they differentiate among emotions at all, differentiate among the two known dimensions along which emotions vary (valence and arousal). A stronger test of the notion that perceptual dimensions differentiate among emotions would be to show that they differentiate among emotions that are similarly categorised in terms of valence and arousal. Thus, we also assess whether perceptual dimensions go beyond valence and arousal by significantly differentiating among emotions that share similar arousal × valence designations (e.g., anger vs. fear; sadness vs. guilt; excitement vs. pride and contentment vs. gratitude; Figure 1).

Based on the logic above, we should be able to assess differentiation by estimating 6 models for Study A, and the same 6 models for study B: (1) differentiating positive from negative emotions; (2) differentiating high arousal from low arousal emotions, (3) differentiating high arousal positive emotions (excitement vs. pride) from each other, (4) differentiating low arousal positive emotions (contentment vs. gratitude) from each other, (5) differentiating high arousal negative emotions (anger vs. fear) and (6) differentiating low arousal negative emotions (e.g., sadness vs. guilt) from one another.

Differentiation analytical procedure

Differentiation also requires a classification procedure that aligns specific perceptual dimensions with specific emotions. The particular classification approach one takes depends on the nature of the data. Our research question considers binary classification variables (i.e., differentiating positive from negative emotions; high arousal from low arousal emotions; and emotions of the same valence × arousal designation). Moreover, the perceptual dimensions, which are the discriminating variables, are measured on a continuous scale. Given the nature of this data and our research questions, the most appropriate estimation procedure for addressing these questions is logistic regression analysis.

Logistic regression analysis uses the continuously scaled perceptual dimensions to estimate the probability (based on the data) that the perceptual dimension in question is significantly related to one emotion or emotion category vs. another (e.g., anger vs. fear; positive emotions vs. negative emotions). We estimated 12 logistic regression models, as shown in Tables 1 and 2. Table 1 refers to the results of Study A (emotion concept study). Table 2 refers to the results of Study B (experienced emotions study). The perceptual dimensions in both tables are organised according to modality, starting with the perceptual dimensions associated with the gustatory modality (taste and satiety) followed by perceptual dimensions associated with the visual, kinaesthetic, tactile and auditory modalities respectively.

For Study A, Model 1 assesses whether perceptual dimensions discriminate positive emotions from negative emotions. Model 2 assesses whether the dimensions discriminate high arousal emotions from low arousal emotions. Models 3–6 assess whether the perceptual dimensions discriminate among emotions of similar valence × arousal quadrants (e.g., excitement vs. pride, Model 3; contentment vs. gratitude, Model 4; anger vs. fear, Model 5; sadness vs. guilt, Model 6). Models 7–12 in Table 2 provide the same estimation procedures, here for Study B.

Specific research questions regarding differentiation

Our basic research question regarding whether perceptual features differentiate emotions can be further broken into five specific empirical research questions.

Questions 1 and 2

Our first and most fundamental research question asks *whether* perceptual dimensions generally differentiate emotions *either* when respondents consider emotion concepts (Study A) or when they experience emotion episodes (Study B). If none of the 12 models in Tables 1 and 2 are significant, we would have no evidence to support our basic research question. A second question asks whether perceptual dimensions generally differentiate emotions *both*

when respondents consider emotion concepts (Study A) and when they experience emotion episodes (Study B). Strong evidence that perceptual dimensions differentiate emotions would be found if we observe that the LR tests for *all models in both Studies A and Studies B* are significant.

Question 3

A third question asks whether perceptual dimensions differentiate emotions above and beyond arousal and valence. To the extent that emotions similar in classifications of arousal and valence are still differentiable in terms of perceptual dimensions, our studies could offer evidence of meaningful differences.

Question 4

A fourth question asks whether the same *specific perceptual dimension* (e.g., temperature) differentiates emotions in *both* studies A and Study B. This question asks whether the coefficient for a given perceptual dimension is significant and directionally consistent across both studies. Note that there are a number of differences between the studies in (a) emotion task (emotion concept vs. emotion experience), (b) design (within vs. between subjects), (c) subject population (students vs. general population adults) and (d) assessment method (in the lab vs. online). Finding that a specific perceptual dimension differentiates emotions in a significant and directionally congruent way, despite these substantial differences, indicates that the relationship between the perceptual dimension and the emotion(s) in question is relatively robust.

Question 5

A final question asks whether a coefficient associated with a specific perceptual dimension (e.g., temperature) is significant for a model in one of the studies but not the corresponding model in in the other study. Findings pertinent to this question allow one to generate novel theory about what might account for these differences. For example, when respondents consider emotion concepts certain language based associations or bodily sensations associated with a given emotion may not be activated, as they would be when respondents experience a specific episode of an emotion. Although our paper is designed to ask the research questions just described above (as opposed to generating novel theory), we believe the differences between the two studies on the specific perceptual dimension associated with a specific set of emotion comparisons will spur future thinking and research on how the nature of the emotion elicitation task might impact the relationship between emotions on the one hand and perceptual dimensions on the other.

Results

Logistic regression model interpretation

Model form

Each of the six logistic regression models reported in Tables 1 and 2 is estimated by the equation:

$$\ln[p/(1-p)] = a + B'X,$$

where ln is the natural logarithm; p is the probability that the emotion (or emotion group) is one vs. another; B is a vector of parameters; and X is a vector of all 29 perceptual dimensions. To illustrate, in Model 1 in Table 1 and Model 7 in Table 2, we compare positive emotions with negative emotions in Studies A and B respectively. As the column headings of Models 1 and 7 show, we assigned a value of 1 to the positive emotions of excitement, pride, gratitude and contentment, and assigned a value of 0 to the negative emotions of anger, fear, sadness and guilt. Likewise, in Model 2 in Table 1 and Model 8 in Table 2 we assigned a value of 1 to the high arousal emotions of excitement, pride, anger and fear and a value of 0 to the low arousal emotions of contentment, gratitude, sadness and guilt.

Model estimates

The logistic regression analysis in Model 1 estimates the probability that the perceptual dimension (e.g., taste) differentiates positive emotions (value = 1) from negative emotions (value = 0). The Likelihood Ratio Test (LR test) in the last row of Tables 1 and 2 is a statistical test of the model, including the perceptual dimensions compared to a model with only the constant. A significant LR test means that the model with the perceptual dimensions is better than a model with only the constant. Table 1 shows that the LR test for Model 1 (448.573) is highly significant, suggesting that perceptual dimensions do indeed differentiate positive from negative emotions. McFadden's R^2 (shown in the next to the last row of each model in Tables 1 and 2) is a calculation of the model's goodness-of-fit (McFadden, 1974). While this measure is not the same as an R^2 for linear regression models (i.e., these R^2s cannot be compared to other studies using other estimation models, such as

analysis of variance), this metric gives one an indication of explained variance. To illustrate, McFadden's R^2 for Model 1 is .76.

Coefficients for specific perceptual dimensions

Models 1–12 also show which perceptual dimensions differentiate the emotions specified by the model. For example, in Model 1, the coefficients for taste, brightness, openness, shape, thickness, pressure and texture are each significant, suggesting that these perceptual dimensions differentiate positive from negative emotions in Study A. The sign of the coefficient indicates the nature of that difference. The third column in Tables 1 and 2 show the anchors of each perceptual dimension. For example, "sour" anchors the negative end of the taste continuum, whereas "sweet" anchors the positive end. The fact that the taste coefficient for Model 1 is positive (+) means that compared to negative emotions (value = 0), positive emotions (value = 1) are more likely to be characterised as sweet. Compared to positive emotions, negative emotions are more likely to be described as sour. In the logistic regression model, the beta coefficients, when significant, represent how much the probability increases with a standard deviation increase in the perceptual dimension. Thus, for Model 1 the coefficient for taste can be interpreted to mean that an increase in taste (i.e., more sweet) has a positive effect on the likelihood of the emotion being positive.

Qualitative interpretation

Table 3 represents the perceptual dimension estimates from Tables 1 and 2 in qualitative form. Perceptual dimensions that are significant in both Studies A and B are shown first in each panel and are in bold-faced font. Perceptual dimensions that are significant for Study A but not study B are shown in non-bold faced font. Those that are significant for Study B but not Study A are shown in italics and are the last items shown in each panel of Table 3.

To illustrate the interpretation of Table 3, in Panel B, 13 of the 29 perceptual dimensions differentiate high arousal from low arousal emotions. Speed, temperature, weight, decibel level and softness differentiate high from low arousal emotions in both Studies A and B. Relative to low arousal emotions, high arousal emotions are more likely to be described as fast, hot, lightweight, loud and hard. Thickness, verticality and sharpness differentiate high arousal from low arousal emotions in Study A. Relative to low arousal emotions, high arousal emotions in Study A are more likely to be described as thin, up and sharp. Satiety, depth, stickiness, pressure and texture differentiate high arousal from low arousal emotions in Study B.

Findings relative to the research questions

In light of the exploratory nature of our research and our basic research questions, and given the number of dimensions, emotions, models and significant effects, as well as provided space limitations, we provide general observations regarding the findings as pertinent to our empirical research questions regarding differentiation, as opposed to presenting detailed results for each model individually.

Multiple perceptual dimensions in multiple modalities differentiate emotions

First, and in light of our first and second research questions, we find strong support for the idea that *perceptual dimensions do indeed differentiate emotions*. *All models in both studies are significant*. An additional finding is that perceptual dimensions that differentiate emotions reflect the *full spectrum of sensory modalities*. Thus, perceptual dimensions relevant to the gustatory, visual, kinaesthetic, tactile and auditory modalities each play a role in differentiating at least some of the emotions we examined. Furthermore, perceptual dimensions explain *reasonable variation* in the classification of emotions in each model. Based on these results, we can readily conclude that: (*a) perceptual dimensions do indeed differentiate emotions, and that (b) certain perceptual features are more reliably associated with particular emotions than others*.

Our results also show that *multiple perceptual dimensions differentiate the emotions* examined. For example, Table 1 shows that four (4) perceptual dimensions (satiety, brightness, colour and texture) differentiate the low arousal positive emotion of contentment from gratitude; however, nine (9) perceptual dimensions differentiate the high arousal positive emotions of excitement and pride (colour, openness, curvature, thickness, size, clarity, speed, sharpness and harmony; Table 1). Across the six models shown in Table 1, the modal number of perceptual dimensions differentiating the emotion pairs was eight (8). Table 2 also shows that with the exception of Model 10, multiple perceptual dimensions and multiple sensory modalities differentiated the emotions. Thus, it is clear that multiple perceptual dimensions are

Table 3. Qualitative interpretation of Tables 1 and 2.

Panel A: Positive vs. Negative Emotions		
Positive vs Negative Emotions can be differentiated based on the perceptual dimensions of:	Emotions are more likely to be characterised as **positive (vs. negative)** the more they are described as:	Emotions are more likely to be characterised as **negative (vs. positive)** the more they are described as:
Taste	**Sweet**	**Sour**
Brightness	**Bright**	**Dark**
Openness	Open	Closed
Shape	Square	Round
Thickness	Thick	Thin
Pressure	Strong	Weak
Texture	Smooth	Rough
Solidity	*Solid*	*Fluid*
Size	*Big*	*Small*
Depth	*Shallow*	*Deep*
Verticality	*Up*	*Down*
Weight	*Lightweight*	*Heavy*
Panel B: High Arousal vs. Low Arousal Emotions		
High Arousal vs. Low Arousal Emotions can be differentiated based on the perceptual dimensions of:	Emotions are more likely to be characterised as **high (vs. low) in arousal,** the more they are described as:	Emotions are more likely to be characterised as **low (vs. high) in arousal** the more they are described as:
Speed	**Fast**	**Slow**
Temperature	**Hot**	**Cold**
Weight	**Lightweight**	**Heavy**
Decible level	**Loud**	**Quiet**
Softness	**Hard**	**Soft**
Verticality	**Up**	**Down**
Thickness	Thin	Thick
Sharpness	Sharp	Dull
Satiety	*Hungry*	*Full*
Depth	*Shallow*	*Deep*
Stickiness	*Non-Sticky*	*Sticky*
Pressure	*Weak*	*Strong*
Texture	*Rough*	*Smooth*
Panel C: High Arousal Positive Emotions (Excitement vs. Pride)		
Excitement and Pride can be differentiated based on the perceptual dimensions of:	High Arousal Positive Emotions are more likely to be characterised as **excitement (vs. pride)** the more they are described as:	High Arousal Positive Emotions are more likely to be characterised as **pride (vs. excitement)** the more they are described as:
Colour	**Black and White**	**Multicoloured**
Size	**Small**	**Large**
Speed	**Fast**	**Slow**
Clarity	Cloudy	Clear
Openness	Open	Closed
Curvature	Wavy	Straight
Thickness	Thin	Thick
Sharpness	Dull	Sharp
Harmony	Harmonious	Discordant
Shape	*Square*	*Round*
Depth	*Shalllow*	*Deep*
Temperature	*Hot*	*Cold*
Density	*Airy*	*Dense*
Panel D: Low Arousal Positive Emotions (Contentment vs. Gratitude)		
Contentment and Gratitude can be differentiated based on the perceptual dimensions of:	Low Arousal positive emotions are more likely to be characterised as **contentment (vs. gratitude)** the more they are described as:	Low Arousal Positive Emotions are more likely to be characterised as **gratitude (vs. contentment)** the more they are described as:
Satiety	Full	Hungry
Brightness	Dark	Bright
Colour	Multicoloured	Black and White
Texture	Smooth	Rough
Constriction	*Loose*	*Tight*
Stickiness	*Non-Sticky*	*Sticky*

(*Continued*)

Table 3. Continued.

Panel E: High Arousal Negative Emotions (Anger vs. Fear)		
Anger and Fear can be differentiated based on the perceptual dimensions of:	High Arousal Negative Emotions are more likely to be characterised as **anger (vs. fear)** the more they are described as:	High Arousal Negative Emotions are more likely to be characterised as **fear (vs. anger)** the more they are described as:
Temperature	**Hot**	**Cold**
Solidity	Solid	Fluid
Spaciousness	Crowded	Roomy
Curvature	Wavy	Straight
Expansiveness	Expansive	Contractive
Stickiness	Non-sticky	Sticky
Pressure	Strong	Weak
Decible Level	Loud	Quiet
Taste	*Sour*	*Sweet*
Spaciousness	*Roomy*	*Crowded*
Curvature	*Straight*	*Wavy*
Depth	*Shallow*	*Deep*
Softness	*Hard*	*Soft*
Panel F: Low Arousal Negative Emotions (Sadness vs. Guilt)		
Sadness and guilt can be differentiated based on the perceptual dimensions of:	Low arousal negative emotions are more likely to be characterised as **sadness (vs. guilt)** the more they are described as:	Low Arousal Negative Emotions are more likely to be characterised as **guilt (vs. sadness)** the more they are described as:
Depth	**Deep**	**Shallow**
Density	**Airy**	**Dense**
Taste	Sweet	Sour
Position	Outside	Inside
Expansiveness	Expansive	Contractive
Speed	Slow	Fast
Verticality	Down	Up
Temperature	Cold	Hot
Decible Level	*Quiet*	*Loud*
Texture	*Rough*	*Smooth*

Notes: Bold = Perceptual dimensions differentiating emotions when participants describe emotion concepts or describe specific emotion episodes (Study A and Study B). Non-Italics non-bold = Perceptual dimensions differentiating emotions when participants describe emotion concepts (Study A). Italics non-bold = Perceptual dimensions differentiating emotions when participants describe specific emotion episodes (Study B).

relevant in differentiating the various emotion pairs. Notably, across the 12 models, only one of the 29 perceptual dimensions (breadth) fails to achieve significance in any model. Thus, the perceptual dimensions we examined do indeed appear to be relevant to differentiating specific emotions.

Non-redundancy with arousal and valence

Relevant to our third research question, our results show that perceptual dimensions not only differentiate positive from negative emotions and high arousal from low arousal emotions but also differentiate among emotions that are similar in arousal and valence (see Models 3–6 in Table 1; Models 9–12 in Table 2). Hence, perceptual dimensions go beyond arousal and valence in differentiating specific emotions. The fact that perceptual dimensions differentiate emotions that occupy similar space in the valence × arousal classification scheme of emotions is notable, as it suggests that the perceptual dimensions we examined are not merely proxies for arousal and valence. These findings further point to potentially underexplored ways in which emotions differ.

Notably, perceptual dimensions seem to be least successful in differentiating contentment from gratitude. In Study A, four perceptual dimensions differentiated these emotions, but the R^2 was among the lowest in that study. In Study B only two perceptual dimensions (stickiness and constriction) differentiated these emotions, with the R^2 (.216) being the lowest of the models estimated. One reason for the limited differentiation observed for these emotions might be due to the fact that these emotions may be correlated in real life. When one feels grateful, one may experience a sense of contentment. When contended, one may feel grateful for the state of contentment. This observation is consistent with prior work suggesting a greater degree of blending with positive emotions (Ellsworth & Smith, 1988; Smith & Ellsworth, 1985).

Certain perceptual dimensions differentiate emotions in both Studies A and B

Relevant to our fourth research question, we find that certain perceptual dimensions differentiate the emotions we studied regardless of whether respondents were describing an emotion concept (Study A) or re-experiencing a particular emotion episode (Study B). For example, Panel A in Table 3 shows that "sweet" and "bright" are associated with positive emotions whereas "sour" and "dark" are associated with negative emotions, regardless of the emotion task. Likewise, Panel B in Table 3 shows that the perceptual features of "fast", "hot", "lightweight", "loud", "hard" and "up" correspond with high arousal emotions, whereas "slow", "cold", "heavy", "quiet", "soft" and "down" correspond with low arousal emotions. The only case where we observed no consistency across the studies in a common perceptual dimension was for contentment vs. gratitude. Panel D in Table 3 shows that no perceptual dimension differentiated contentment from gratitude across the two studies.

Finally, and relevant to the fifth research question, we find that some perceptual dimensions differentiate emotions in one study, but not the other (Table 3). For example, lightweight vs. heavy differentiates positive from negative emotions when respondents reflect on and re-experience specific emotion episodes, but not when they simply consider emotion concepts. In light of the differences between these studies, future research should examine whether these differences are attributed to the emotion task or other factors that differentiate the studies (e.g., design and respondents).

Correspondence with and extension of prior research

Also notable is that we see some correspondence between our results and prior research on perceptual features. For example, consistent with Meier et al. (2007), Meier et al. (2004) and Stabler and Johnson (1972), we find that brightness is associated with positive (vs. negative) emotions, whereas darkness is associated with negative (vs. positive) emotions (see Panel A in Table 3). Consistent with Lakoff and Johnson (1980) and Waggoner (2010) heat is (more strongly) associated with anger (than fear; see Panel E in Table 3). Coldness is more strongly associated with sadness (than with guilt; see Panel F in Table 3), a finding consistent with Waggoner (2010). "Down" is associated with sadness (more so than with guilt), consistent with McMullen and Conway (2002) (see Panel F in Table 3).

Yet, our results suggest that there may be value to studying other underexplored dimensions, particularly in light of their statistical significance in our models. For example, whereas prior research has linked brightness to positive emotions, our results suggest that other perceptual dimensions shown in Panel A in Table 3 may be equally viable in differentiating positive from negative emotions, and hence should be considered in future research that links perceptual dimensions to emotions.

Several of the perceptual dimensions that have not been studied in past research also make some intuitive sense in terms of common language and metaphorical expressions. For example, it makes some sense that the perceptual dimensions of taste and texture differentiate positive from negative emotions, with perceptual features like sweetness and smoothness being more strongly linked to positive than negative emotions. Likewise, it makes some intuitive sense based on common metaphorical expressions that the perceptual dimensions of speed, verticality, and decibel level differentiate high arousal from low arousal emotions, with features like fast, up, and loud being more strongly linked to high arousal than low arousal emotions.

Discussion

The present exploratory research provides initial support for the idea that perceptual dimensions differentiate emotions. While these results are not suited for a critical test or integrative account of multiple emotion theories, our findings raise questions regarding the possible drivers of our findings. Based on our observations, several (non-competing) explanations are proposed below. Future research would benefit from further examination of the possible drivers.

Linguistic/metaphorical associations

Some associations may be due to the use of metaphorical expressions of language (e.g., Kövecses, 1986; Lakoff & Johnson, 1980; see also, Landau, Meier, & Keefer, 2010). According to this perspective, metaphoric expressions (known as metonymies) link commonplace concepts (e.g., hot fluid in a bottle) to more abstract target concepts (e.g., anger). For example, consider the metonymies linked to anger—she was

"hot under the collar", "she was simmering with anger", "he was steaming", "he blew his stack". These figures of speech (and others) suggest that anger is cognitively represented as the heat of a fluid in a container (Lakoff & Johnson, 1980).

Meier and Robinson (2004) articulate a number of reasons why perceptual features might be incorporated into metaphors for emotions. First, children come to understand their world first through their perceptual senses. Only later in life, and through cognitive development, do they come to understand abstract concepts like emotions and are they able to develop the ability to think metaphorically. In addition, we grow up in a world where metaphorical representations are part of how we communicate. To the extent that a metaphorical association forms between a concrete perceptual state and an abstract concept, and that association is reinforced over time, the perceptual feature may become intimately tied to the emotion concept itself.

Conceptual knowledge of emotions and emotion categories

Prototype theories of emotion (e.g., Shaver, Schwartz, Kirson, & O'Connor, 1987) provide evidence that individuals have conceptual knowledge about emotions. Hence, perhaps these perceptual dimensions differentiate emotions because they are associated with elements of an emotion prototype (i.e., its antecedents, consequences or manifestations). For example, perhaps "sadness" is characterised as "down" relative to its low arousal negative emotion counterpart of guilt, because when one feels sad one's mouth and body posture slump (how sadness is represented in the body) and because when one feels sad one experiences a physical desire to lie down. High arousal emotions may be characterised as more "loud" than low arousal emotions because these feelings evoke motivations to shout (with anger or pride) or scream (with fear or excitement). Hence, perhaps these perceptual features represent abstract *knowledge about the body when one feels a specific emotion as well as generalised bodily consequences* from specific emotion states. For example, when we experience "anger", "excitement" and "pride" we often experience increased heart rate and blood pressure. These somatic changes may create body temperature changes that make an individual feel hot. Hence heat may be a somatic analogue to anger, excitement, and pride. Perhaps as well, certain perceptual features characterise emotions because they are associated with generalised knowledge about the situations in which specific emotions tend to occur. That positive emotions are linked with bright whereas negative emotions are described as dark may be explained by the fact that good things often happen in the day when there is a lot of social interaction, whereas introspective emotions like guilt, fear and sadness arise more at night when it is dark and one is alone with one's thoughts.

Differences based on emotion task

Future research should examine the nature of the differences in perceptual dimensions that differentiate emotions in one study but not the other. It is certainly possible that re-experiencing an emotion makes particular perceptual dimensions salient that are less salient when emotion concepts are activated. For example, Panel D shows that constriction differentiates contentment and gratitude when respondents re-experience the emotion, but not when they consider these emotions as concepts. It is possible that re-experiencing contentment (vs. gratitude) leads individuals to feel looseness in their jaws and muscles, since contentment is a state of relaxation. In contrast, tightness may be more associated with gratitude than contentment because gratitude may imply a motivation to reciprocate towards the source of one's gratitude, leading to an action orientation that activates muscles. Clearly additional theory and evidence is needed to explore these differences. Future research can also examine whether these differences are attributed to the emotion task or whether other factors endemic to these studies contribute to the observed differences between the studies.

Future research may also examine the extent to which these results replicate when employing bipolar scales. We note that our perceptual dimensions findings were collected as constituent perceptual features (i.e., feature level ratings (e.g., hot and cold) for each dimension (e.g., temperature)). This method was used to ensure that a dichotomy was not forced artificially, to allow for the possibility that a given emotion could be described as high or low in both features (e.g., both hot *and* cold), and to empirically assess whether that occurred. After determining that participants did indeed treat constituent features as anchors of a dimension, we proceeded with dimension level analyses for parsimony in our studies.

Conclusion

In summary, beyond discovering that perceptual dimensions do differentiate specific emotions, and that specific emotions and emotion groupings are characterised by perceptual dimensions from multiple sensory modalities (e.g., gustatory, visual, kinaesthetic, tactile and auditory), our findings offer a number of interesting ideas regarding the theoretical underpinnings and suggest promising directions for future research on emotion-perceptual dimension and feature-specific linkages with important implications for judgements, decisions and behaviour. Clearly this domain is rich with potential.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix A

Illustration task

Before we begin we would like to help you better understand the exercise that we will ask you to do. Below we will walk you through a short example to

give you a better feel for the task that you will do in today's session.

Sample Emotion: Amusement

AMUSEMENT

Imagine a situation when you felt AMUSEMENT and what AMUSEMENT feels like.

To what extent do these words below describe *this* feeling?

	Not at all						*Very much*
Solid		*X*					
Fluid					*X*		
Hot				*X*			
Cold	*X*						
Heavy		*X*					
Light						*X*	
Soft			*X*				
Hard		*X*					
Sticky						*X*	