The temperature dimension of emotions

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Abstract

Purpose – The literature to-date has focused on dimensions of emotions based on emotions' affective *state* (captured by valence, arousal and dominance, PAD). However, it has ignored that emotional reactions also depend on emotions' *functionality* in serving to solve recurrent adaptive problems related to survival and reproduction. Evolutionary psychology suggests that relationships with others are the key that helps individuals reach both goals. The purpose of this paper is to conceptualize, measure and validate the temperature dimension of emotions that underlies such human relationships, as suggested by frequent verbalization of emotional states via temperature-related terms ("cold fear" and "warm love").

Design/methodology/approach – Across three studies ($n_{Study1a}$ = 71; $n_{Study1b}$ = 33; and n_{Study2} = 317) based on samples from two countries (Germany and the USA) and using two different methods (semantic and visual), the temperature dimension of emotions is conceptualized and measured. Across a wide spectrum of emotions, factor analyses uncover temperature as an emotional dimension distinct from PAD and assess the dimension's face, discriminant, convergent, nomological and criterion validity.

Findings – Emotional temperature is a bipolar dimension of an affective state that underlies human relationships, ranging from cold to warm, such that social closeness is linked to emotional warmth and social distance to emotional coldness. Emotional temperature is uncovered as a dimension distinct from PAD, that is, it is correlated with but separate from PAD.

Research limitations/implications – In this research, a portfolio of 17 basic emotions relevant in everyday consumption contexts was examined. Future research could further refine the emotional temperature dimension by analyzing more complex emotions and their position on the temperature map. In general, this paper sets the stage for additional work examining emotional temperature and its effects on consumer behavior.

Practical implications – The results have strategic implications for marketers on which emotions to select for campaigns, depending on factors like the climate or season.

Social implications – This research provides a better foundation upon which to understand the effect of emotions that invoke warmth or coldness.

Originality/value – To the best of the authors' knowledge, this research is the first to conceptualize, measure and comprehensively validate the temperature dimension of emotions.

Keywords Emotional temperature, Emotions, Dimension of emotions, Emotional warmth, Emotional coldness, Affect

Paper type Research paper

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Introduction

People often associate emotions with temperature. Love and joy, for example, feel warm, while envy and loneliness feel cold. Temperature is also common in metaphors used to describe emotional reactions: people are given the "cold shoulder" when they are excluded, while romantic love can feel "hot"; people can be "cold-hearted," but hearts can also "melt." People implicitly link specific emotions to emotional warmth and coldness or, more generally, to emotional temperature in verbal expressions. This behavior suggests that emotional temperature is a dimension that underlies individual emotions and that each discrete affective state has a certain "degree" of temperature. There is some preliminary support for this view in neuroscience, which suggests that the same brain region (i.e. the insular cortex) is implicated in the processing of both physical temperature (Craig *et al.*, 2000) and emotional temperature (Williams and Bargh, 2008).

To date, however, practitioners and academics have little empirically supported guidance regarding the relationships between individual emotions and emotional temperature (Zhang *et al.*, 2014). This is surprising given practitioners' widespread reliance on emotional temperature in marketing campaigns. For example, emotionally cold appeals are widespread in advertising, especially in social marketing campaigns, such as shock ads for HIV prevention (Duhachek *et al.*, 2012; Keller and Lehmann, 2008) or non-smoking campaigns (Wall, 2005). In a similar vein, retailers often rely on campaigns using warm emotions. For example, the British retailer John Lewis annually launches a touching Christmas ad to kick off the holiday season which achieves internet buzz and extensive media coverage. Global brands ranging from Coca-Cola to Disney have similarly used warmth in their advertising. Prior work has consistently demonstrated that emotional warmth increases positive attitudes towards the ad and brand and eventually purchase likelihood (Aaker *et al.*, 1986; Ohlwein and Bruno, 2021; Vanden Abeele and MacLachlan, 1994).

In marketing research, a growing body of evidence finds that emotional temperature influences consumers' responses (Aaker *et al.*, 1988; Bruno *et al.*, 2017; Bruyneel *et al.*, 2009; Pham *et al.*, 2013). Yet, there is an ongoing debate about the conceptualization. For example, Aaker *et al.* (1986, p. 366) defined emotional warmth as "a positive, mild, volatile emotion involving physiological arousal and precipitated by experiencing directly or vicariously a love, family, or friendship relationship." Subsequent research has questioned this view of emotional warmth, particularly challenging its discriminant validity relative to other individual emotions (Aaker *et al.*, 1988; Vanden Abeele and MacLachlan, 1994). Aaker *et al.* (1988) found that warmth itself is composed of several discrete emotions and suggested that it has previously been studied at a too high level of aggregation. Vanden Abeele and MacLachlan (1994, p. 599) conclude that emotional warmth "is vaguely defined and overlaps with other emotions (e.g. love, pleasure, attraction), and it has not been studied very thoroughly."

Emotional coldness is even less well understood. Research suggests that some emotions may be linked to "coldness" – for example, those experienced following betrayals of trust in an economic game (Kang *et al.*, 2011) – but the construct has not been clearly conceptualized and little is known about the marketing implications of the bipolar nature of emotional temperature. Nevertheless, people are commonly described as emotionally "cold" using terms such as "cold-hearted, inaccessible, detached, self-absorbed, insulated, excessively independent, haughty and untrusting or angry" (Seltzer, 2011). Although not all these words directly involve emotions, they signal that emotional coldness is multiply composed and that individual emotions are related to a sense of autonomy. Examples of individual cold emotions from prior research consistently include loneliness (Zhong and Leonardelli, 2008),

unhappiness (Williams and Bargh, 2008), embarrassment and guilt (Eisenberger *et al.*, 2003; Kross *et al.*, 2007).

The current research elevates our understanding of emotional temperature as a latent construct that underlies a variety of distinct individual emotions. This work contends that temperature is a dimension of emotions – akin to valence, arousal or dominance – that underlies human relationships and has important implications across a wide range of human behaviors, from psychological treatments (Bargh and Shalev, 2012) to responses to marketing stimuli in everyday life (Vanden Abeele and MacLachlan, 1994). The goal of this research is to conceptualize, measure and validate the temperature dimension of emotions and examine it relative to the established Pleasure–Arousal–Dominance (PAD) dimensions, across two different assessment approaches (semantic and visual). While PAD captures affective state, emerging evidence on emotions coming from the field of evolutionary psychology (Griskevicius *et al.*, 2009, 2010) suggests that besides this affective *state* (captured by PAD), the effects of different emotions also depend on their *functionality* in serving to solve recurrent adaptive problems related to survival and reproduction (Griskevicius *et al.*, 2009). Relationships with other humans are the key that helps individuals reach both of those goals. Yet, PAD does not capture this important aspect of emotions, a gap this research seeks to address.

In doing so, this research makes several important contributions to the literature. First, by introducing and validating temperature as a distinct dimension of emotions, this research connects disperse streams of literature on "warm" (Griskevicius *et al.*, 2010; Khoshghadam *et al.*, 2019) and "cold" (Duhachek *et al.*, 2012) emotions in a novel light and opens new avenues for research. Importantly, our results suggest that the "emotional temperature" dimension is not limited to individual emotions but may also extend to the temperature of a situation or an image, thus contributing to emerging research in this domain (Hadi and Block, 2019). Second, this work addresses a call in the literature to improve the understanding of emotions by essentially introducing a new theoretical lens to investigate additional dimensions of emotions to complement the established ones (Fontaine *et al.*, 2007; Laukka *et al.*, 2005). Specifically, this new dimension allows emotions to be assessed based on their *functionality* in solving recurrent adaptive problems related to survival and reproduction (Griskevicius *et al.*, 2009, 2010), in this case, via human relationships, rather than simply measuring affective states. Third, it contributes to the debate on the nature of emotional warmth by providing empirical evidence that "emotional warmth" constitutes one end of the emotional temperature dimension spectrum (Aaker *et al.*, 1988; Lopez-de-Ipiña *et al.*, 2015; Vanden Abeele and MacLachlan, 1994). Finally, from a managerial perspective, the results have important implications for the use of warmth or coldness in marketing campaigns.

Dimensions of emotions

To better understand the wide range of human emotional experience, psychology has examined dimensions of emotions for more than a century (James, 1884; Wundt, 1896). Wundt (1896) was a pioneer in using this approach, theorizing that emotions can be conceptualized in a three-dimensional space consisting of valence (positive-negative), arousal (calm-excited) and tension (tense-relaxed). Subsequent work has reinforced the importance of valence and arousal (Khoshghadam *et al.*, 2019; Noseworthy *et al.*, 2014). Research has also suggested additional dimensions that include dominance, attention, experience and predictability (Table 1).

Russell and Mehrabian's (1977) PAD model has been especially influential (Olney *et al.*, 1991) and so far has received the greatest attention in consumer research (Havlena and

Studies	Pleasure	Arousal	Dominance	Attentional activity	Depth of experience	Unpredictability
Schlosberg (1952)	x			x		
Schlosberg (1954)	x	x		x		
Osgood (1955)	x	x	x			
Block (1957)	x	x				
Engen *et al.* (1958)	x	x		x		
Triandis and Lambert (1958)	x	x		x		
Abelson and Sermat (1962)	x	x				
Bush (1973)	x	x	x			
Averill (1975)	x	x	x		x	
Bottenberg (1975)	x	x			x	
Russell and Mehrabian (1977)	x	x	x			
Russell (1978)	x	x	x		x	
Russell (1980)	x	x				
Daly *et al.* (1983)	x	x			x	
Russell (1983)	x	x				
Holbrook and Batra (1987)	x	x	x			
Yik *et al.* (1999)	x	x				
Fontaine *et al.* (2002)	x	x	x			
Fontaine *et al.* (2007)	x	x	x			x

Source: Adapted from Smith and Ellsworth (1985)

Table 1. Overview of emotional dimensions in the literature

Holbrook, 1986; Olney *et al.*, 1991). The PAD emotional state model conceptualizes three bipolar emotional dimensions:

Pleasure (in the following referred to as valence)

The dimension of pleasure or valence ranges from positive or pleasant to negative or unpleasant (Clore, 1994; Watson and Spence, 2007). For example, joy is a positive emotion, while sadness is negative. In general, pleasure serves as a parsimonious description of behaviors a person might have in reaction to a positive or negative stimulus (Mehrabian and Russell, 1974; Olney *et al.*, 1991). Specifically, an exposure to an emotionally positive stimulus (e.g. nostalgic effects in advertising) can lead to a favorable consumer reaction, such as a better mood (Gardner, 1985), enhanced attitude towards advertisements or a brand (Burke and Edell, 1989; Goldberg and Gorn, 1987; Holbrook and Batra, 1987) or increased purchase likelihood (Donovan *et al.*, 1994; Khoshghadam *et al.*, 2019).

Arousal

The dimension of arousal is the activation state of emotion, ranging from calm and sleepy to excited and frantic (Clore, 1994; Fan *et al.*, 2015; Mehrabian and Russell, 1974). For example, while anger and rage are both negative emotions, rage has a higher arousal state than anger. Arousal reflects the experience of energy mobilization (Russell and Barrett, 1999). It is the feeling of energy that corresponds to physical changes that prepare a body for action – for example, pupil dilation (Beatty, 1982), elevated heart rate (Pham, 1996) or higher blood pressure (Sanbonmatsu and Kardes, 1988). Importantly, research has demonstrated that arousal plays an important role in our understanding of consumer behavior across a variety of different contexts (Andrade, 2005; Di Muro and Murray, 2012; Holmqvist and Lunardo,

2015). For example, Noseworthy *et al.* (2014) demonstrated that varying arousal subsequently varies the severity of an activated emotion, which in turn affects product evaluations; Fedorikhin and Patrick (2010) revealed that elevated arousal interferes with consumers' ability to self-regulate and resist temptations; and Yin *et al.* (2017) found that arousal impacts consumers' perceptions of online reviews.

Dominance

The dimension of dominance describes the degree to which persons feel unrestricted, in control of a situation and free to act in a variety of ways (Mehrabian and Russell, 1974). Mehrabian (1996, p. 2) explained dominance as "feelings of control and influence over everyday situations, events and relationships versus feelings of being controlled and influenced by circumstances and others." For example, while anger and fear are negative emotions, anger is a dominant emotion, while fear is a submissive emotion. Recent work has described dominance as an individual's sense that they can affect their environment and found fMRI evidence in support of the role of dominance as a dimension of emotions (Jerram *et al.*, 2014). In consumer research, dominance has played a role in understanding consumers' responses to retail environments (Yani-de-Soriano and Foxall, 2006; Massara *et al.*, 2010).

While PAD dimensions are universal, they do not specifically consider the functionality of different emotions. This impedes understanding of why, for example, emotions of similar valence (e.g. sadness, anger and fear) show different action tendencies (Hosany *et al.*, 2021). Research over the past decade has emphasized that PAD dimensions are insufficient to explain emerging evidence on emotions coming from the field of evolutionary psychology (Griskevicius *et al.*, 2009, 2010). Specifically, it suggests that the effects of different emotions depend on not only the affective *state* (captured by PAD) but also their *functionality* in serving to solve recurrent adaptive problems related to survival and reproduction (Griskevicius *et al.*, 2009). Relationships with other humans are important in the achievement of both of those goals (Winston *et al.*, 2002). Yet, PAD does not capture this key aspect of emotions. Hence, this research introduces emotional temperature which underlies human interactions and conceptualizes, measures and comprehensively validates temperature as a dimension of emotions. Because of the expected universality of the dimension, the approach recommended by Fontaine *et al.* (2007) is followed to test and validate the proposed dimension against the established universal PAD dimensions. To be clear, consistent with prior research (Solomon and Stone, 2002), emotional temperature is expected to correlate with other established dimensions, including valence. This research argues, however, that the temperature dimension differs from other dimensions of emotions in the way that it uniquely underlies emotional experiences that reflect outcomes of human relationships.

Emotional temperature

This paper defines emotional temperature as a bipolar dimension of an affective state that underlies human relationships, ranging from cold to warm, such that social closeness is linked to emotional warmth and social distance to emotional coldness. Physical temperature and closeness to other people are fundamental to human survival and are concepts learned through early experience (IJzerman and Semin, 2009; Inagaki and Eisenberger, 2013). As infants, people learn that proximity to others and physical warmth (or lack thereof) co-occur with particular emotional experiences (Hall, 1966; Lakoff and Johnson, 1980). For example, being held close by a parent, which is connected with emotions such as love, produces bodily warmth. In contrast, being alone – that is, being physically distant from others and feeling

emotions such as loneliness – results in physical coldness (Zhong and Leonardelli, 2008). Consequently, physical and emotional temperature are often experienced simultaneously and, as a result, become mentally linked. Thus, from early infancy on, humans store those complex concepts of emotional warmth and coldness as opposites, which are linked to the bodily experiences of physical warmth and coldness, and are associated with human interactions. Consequently, emotions such as joy, love and contentment become associated with warmth. In contrast, loneliness, sadness and discontent become associated with coldness.

Emerging fMRI studies provide empirical evidence for a shared neural mechanism by which the brain processes physically warm stimuli and the feelings associated with connecting with close others (Inagaki and Eisenberger, 2013). Thus, emotional temperature is closely linked to physical temperature and emotions resulting from social relationships. Marketing research supports this view. For example, people who experience social isolation feel physically colder and demonstrate a preference for warm food and drinks (Zhong and Leonardelli, 2008). Relatedly, people exposed to physical coldness indicate a higher willingness to pay for romantic movies arousing love and joy (i.e. emotional warmth; Hong and Sun, 2012). In a similar vein, people who strive to be perceived as warmer are more likely to buy products that everyone else is buying to feel connected to others (Van der Lans *et al.*, 2016). Yet, when people feel physically hot, they respond better to ads that display cold emotions (Bruno *et al.*, 2017). Finally, warmth, as compared to competence, is seen as the primary dimension of social perception – it allows people to assess the other's perceived positive or negative intent in a social context (Cuddy *et al.*, 2008; Hess and Melnyk, 2016).

To summarize, this paper proposes that emotional temperature underlies an evolutionary mechanism that builds on affective consequences of relationships and helps people to determine whether to approach or retreat from a relationship or other social interactions, with emotional warmth at one pole and emotional coldness at the other. For example, love is expected to be a warm emotion because it promotes social relationships – after all, people want to be close to those they love. In contrast, consistent with Greenaway *et al.* (2018), although pride is also a positively valenced emotion (Remington *et al.*, 2000), its emotional temperature is colder because it creates social distance (i.e. feeling superior to others). As another example, worry is a negatively valenced emotion (Borkovec *et al.*, 1998), but its emotional temperature is relatively warm because it is associated with the intent to be close to others to receive or provide support. This conceptualization not only accounts for the fact that emotional warmth overlaps with individual emotions – by putting it on a higher hierarchical level – but also sheds light onto the previously overlooked nature of emotional coldness.

Overview of studies

The temperature dimension of emotions is empirically measured and comprehensively validated via three studies (following the procedure in Russell *et al.*, 1989). The goal of the three studies is to factor-analytically establish temperature as an emotional dimension distinct from the established PAD dimensions of valence, arousal and dominance. If emotional temperature is indeed a separate dimension not currently captured by the three PAD dimensions, then a four-factor structure is expected to emerge across the studies. Hence, the studies are organized as follows. First, exploratory factor analyses (EFAs, Studies 1 and 2) investigate whether a four-factor solution emerges such that items hypothesized to assess emotional temperature indeed load onto a factor distinct to the established PAD dimensions. Second, a subsequent confirmatory factor analysis (CFA) validates the theory-based four-factor structure (Study 2). Specifically, Studies 1a and 1b

serve as a first exploratory assessment of emotional dimensions for a German-speaking sample across two methods:

(1) semantic approach (using words, Study 1a, e.g. Fontaine *et al.*, 2002; Fugate *et al.*, 2018); and

(2) visual approach (using emotional imagery, Study 1b, e.g. Abelson and Sermat, 1962; Davis *et al.*, 1995; Watson and Tellegen, 1985).

Across both methods, emotional temperature is factor-analytically (EFA) uncovered as a dimension distinct from valence, arousal and dominance (the PAD dimensions) across a wide spectrum of emotions. Namely, the results reveal that the dimension of emotional temperature is separate from the established PAD dimensions, irrespective of whether participants evaluate emotion words or emotional imagery.

Study 2 builds on a comprehensive sample to further assess the robustness and validity of the emotional temperature dimension, using a sample from a different country (the USA). Importantly, Study 2 also has two additional goals. First, it establishes configural invariance by testing whether the dimensional factor structure holds within and across the emotional groups of positive versus negative emotions. Second, Study 2 addresses criterion validity – that is, the extent to which the proposed emotional temperature dimension correlates with another variable that is theoretically expected to be correlated. One of the closest established constructs related to human relationships is the concept of social proximity. Hence, the emotional temperature dimension should correlate with social proximity, a notion that is empirically addressed to prove criterion validity in Study 2.

Study 1: Emotional temperature as a distinct emotional dimension – the factor structure

Using different assessment approaches (semantic vs visual), Study 1 serves as a first exploratory indicator to uncover emotional temperature as an emotional dimension distinct from other established emotional dimensions. Consequently, Studies 1a and 1b test whether emotional temperature emerges as an additional emotional dimension in the first place.

Study 1a: Semantic approach

The goal of Study 1a is to provide initial empirical evidence for the emotional temperature as an emotional dimension distinct from other established emotional dimensions using a *semantic approach*.

Method

Participants. In exchange for the chance of winning a cash prize in a lottery, 71 respondents (44 females) between 19 and 68 years of age (M = 31.21, SD = 11.89) participated in an online survey. The survey link was distributed through social media platforms and university websites, exclusively to German-speaking participants. As Studies 1a and 1b acted mainly as a first check of the emergence of emotional temperature among emotional dimensions, a web-based convenience sampling approach was chosen, allowing for rapid data collection (Etikan *et al.*, 2016). Sample sizes for both Studies 1a and 1b were determined before any data analysis.

Procedure and materials. Participants saw a list of 17 emotion words (such as "love" or "fear" in German language, native to the participants; see Table 2 for the list of included emotions and Appendix 3 for the full phrasing of the questions). These were presented in a randomized order across respondents. The selection of emotion words was based on the Consumption Emotions Set (CES; Richins, 1997) which consists of semantic descriptors for a

Table 2. Overview of emotions included in Studies 1a and 1b

Study 1a (semantic approach)	Study 1b (visual approach)
Anger	Anger
Contentment	
Discontent	
Disgust	Disgust
Envy	Envy
Excitement	Excitement
Fear	Fear
Joy	Joy
Loneliness	
Love	Love
Peacefulness	
Pride	Pride
Romantic Love	Romantic Love
Sadness	Sadness
Shame	
Surprise	Surprise
Worry	Worry

broad coverage of consumption-related emotion states. Ultimately, the 16 main descriptors of the CES and one additional CES descriptor (pride) were selected which is also commonly associated with consumption situations, particularly those involving high status.

For each emotion word, participants indicated the level of association with 13 items on a seven-point bipolar adjective scale (−3 to +3)[1] in the general spirit of the semantic differential (Osgood *et al.*, 1957). The 13 items consisted of four items for the established dimension of valence (unpleasant/pleasant; bad/good; negative/positive; and miserable/delightful) and three items for the established emotional dimensions of arousal (calm/excited; relaxed/stimulated; and inactive/active), dominance (submissive/dominant; weak/strong; and powerless/powerful), respectively, and for the emotional temperature dimension (emotionally cold/emotionally warm; not touching/touching; and coldhearted/warmhearted; Table 4). The items for the emotional dimensions originate from previous literature. Specifically, the PAD semantic differential measures of emotional state were adapted for the items on the established dimensions (Mehrabian and Russell, 1974; Russell and Mehrabian, 1977), while the emotional temperature items were based on the relatively limited literature on emotional warmth (Aaker *et al.*, 1986, 1988; Burke and Edell, 1989). Key items which are close in their meaning to the eventual factors (key indicants or marker variables, like emotionally cold/emotionally warm, negative/positive, calm/excited and submissive/dominant) were included to facilitate validation of the derived factors (Hair *et al.*, 2018). The order of these scales was randomized to avoid response biases.

Results and discussion

To uncover the emotional temperature dimension, an EFA was conducted on the 13 bipolar adjective scales across all observations and participants using a maximum likelihood estimator and oblimin rotation in Mplus 6.1 (R factor analysis), after an assessment that the items showed sufficient correlations to justify a factor analytical approach (Appendix 1). The maximum likelihood estimator was selected because it allowed to compute goodness of fit indices of the model, test factor loading significance and assess factor correlations and their confidence intervals (Cudeck and O'Dell, 1994; Fabrigar *et al.*, 1999). An oblique rotation technique was used, as it was expected that emotional temperature was likely to

correlate to a certain degree with the PAD emotional dimensions, particularly valence (Hair *et al.*, 2018). A (common) factor analysis (in lieu of a component analysis) was appropriate in this study because emotion literature suggests specific relationships between the individual items and how they might group themselves into factors (Hair *et al.*, 2018). Further, (oblique) factor analyses remove random error from the factors, so that the relations among factors represent the population values more adequately, in contrast to component analyses which generally underestimate relations among the constructs (Fabrigar *et al.*, 1999).

A four-factor solution emerged as the most parsimonious factor solution for which goodness of fit statistics fulfilled established rules of thumb (RMSEA $\leq$ 0.08; CFI $\geq$ 0.9; TLI $\geq$ 0.9; and SRMR $\leq$ 0.08; Byrne, 2001; Hair *et al.*, 2018; Hu and Bentler, 1998, 1999; Table 3), also confirmed by the scree plot and factor interpretability considerations.

Table 4 displays the rotated standardized factor loadings. Factor loadings greater than |0.5| are considered as strong and are shaded (Hair *et al.*, 2018). These loadings were statistically significant ($p < 0.001$).The factor loading matrix revealed a simple structure solution (one high factor loading for each variable on only one factor; Hair *et al.*, 2018), that is, there were no substantial cross-loadings, which resulted in a straightforward factor interpretation. Importantly, the uncovered pattern of factor loadings corresponded to the expected factor structure. Namely, emotional temperature emerged as a latent factor distinct from valence and was defined by the items emotionally cold/emotionally warm, coldhearted/warmhearted and not touching/touching. The other three factors reflect the established emotional dimensions of valence, arousal and dominance, overall providing high face validity (see Table 4 for factor correlations).

In sum, the results in Study 1a confirm the face validity of the dimension of emotional temperature and give a first indication of its discriminant validity through the distinction between the valence dimension and the emotional temperature dimension.

Study 1b: Visual approach

Study 1b aims to replicate the factor structure detected in Study 1a and to address its internal reliability by establishing distinctiveness of emotional temperature from other established dimensions using a different method, that is, a visual approach. Specifically,

Study	Factors	Chi-square X^2	*df*	*p*	RMSEA	SRMR	CFI	TLI	Negative residual variance
Study 1a	1	3,115.864	65	0.000	0.200	0.144	0.789	0.747	NO
	2	930.814	53	0.000	0.119	*0.038*	0.939	0.911	NO
	3	594.940	42	0.000	0.106	*0.026*	*0.962*	0.929	NO
	4	116.908	32	0.000	*0.048*	*0.008*	*0.994*	*0.986*	NO
Study 1b	1	1,428.195	65	0.000	0.230	0.188	0.701	0.641	NO
	2	471.528	53	0.000	0.141	*0.048*	0.908	0.865	NO
	3	220.952	42	0.000	0.104	*0.032*	*0.961*	0.927	NO
	4	52.575	32	0.012	*0.040*	*0.008*	*0.995*	*0.989*	NO

Notes: CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; italic type denotes satisfactory goodness of fit indices (RMSEA $\leq$ 0.08; CFI $\geq$ 0.9; TLI $\geq$ 0.9; SRMR $\leq$ 0.08) (Byrne, 2001; Hair *et al.*, 2018; Hu and Bentler, 1998, 1999)

Table 3. Goodness of fit indices of alternative factor solutions (Studies 1a and 1b)

Table 4.
Standardized oblimin factor loading matrix and factor correlations (Study 1a)

Factor loadings/ correlations	Item/factor	Factor 1 (Temperature)				Factor 2 (Valence)				Factor 3 (Dominance)				Factor 4 (Arousal)			
		Est.	*SE*	*Est./SE*	*p-value*	*Est.*	*SE*	*Est./SE*	*p-value*	*Est.*	*SE*	*Est./SE*	*p-value*	*Est.*	*SE*	*Est./SE*	*p-value*
Factor loadings	Cold/ warm	*0.790*	*0.055*	*14.387*	*0.000*	0.104	0.054	1.927	0.054	0.002	0.025	0.099	0.921	0.067	0.016	4.235	0.000
	Coldhearted/ warmhearted	*0.673*	*0.061*	*10.979*	*0.000*	0.241	0.060	4.000	0.000	0.074	0.026	2.822	0.005	−0.055	0.018	−3.078	0.002
	Not touching/ touching	*0.576*	*0.050*	*11.442*	*0.000*	0.002	0.047	0.046	0.963	0.170	0.043	3.909	0.000	−0.031	0.032	−0.975	0.330
	Unpleasant/ pleasant	−0.009	0.016	−0.588	0.557	*0.960*	*0.016*	*59.669*	*0.000*	0.012	0.014	0.848	0.396	−0.016	0.011	−1.451	0.147
	Negative/ positive	0.039	0.015	2.545	0.011	*0.950*	*0.016*	*59.453*	*0.000*	−0.016	0.013	−1.217	0.224	0.012	0.010	1.220	0.222
	Bad/ good	0.069	0.016	4.277	0.000	*0.902*	*0.016*	*54.784*	*0.000*	0.017	0.014	1.180	0.238	−0.015	0.011	−1.365	0.172
	Miserable/ delightful	0.066	0.021	3.100	0.002	*0.853*	*0.022*	*39.331*	*0.000*	0.039	0.018	2.133	0.033	0.025	0.015	1.696	0.090
	Weak/ strong	0.127	0.026	4.789	0.000	−0.082	0.015	−5.397	0.000	*0.879*	*0.022*	*39.312*	*0.000*	−0.059	0.013	−4.443	0.000
	Powerless/ powerful	−0.047	0.026	−1.836	0.066	0.131	0.040	3.262	0.001	*0.771*	*0.041*	*18.804*	*0.000*	0.048	0.030	1.606	0.108
	Submissive/ dominant	−0.144	0.043	−3.365	0.001	0.110	0.051	2.160	0.031	*0.544*	*0.048*	*11.411*	*0.000*	0.142	0.038	3.714	0.000
	Inactive/ active	0.044	0.038	1.159	0.246	0.060	0.046	1.318	0.188	*0.533*	*0.044*	*12.067*	*0.000*	0.283	0.038	7.402	0.000
	Calm/ excited	−0.079	0.026	−3.062	0.002	0.111	0.020	5.556	0.000	0.081	0.036	2.235	0.025	*0.867*	*0.047*	*18.460*	*0.000*
	Relaxed/ stimulated	0.182	0.032	5.787	0.000	−0.229	0.051	−4.482	0.000	−0.040	0.043	−0.930	0.352	*0.706*	*0.049*	*14.517*	*0.000*
Factor correlations	Factor 1	1	–	–	–												
	Factor 2	0.803	0.029	27.739	0.000	1	–	–	–								
	Factor 3	0.510	0.036	13.972	0.000	0.594	0.021	27.809	0.000	1	–	–	–				
	Factor 4	0.079	0.031	2.578	0.010	0.045	0.030	1.517	0.129	0.495	0.026	18.997	0.000	1	–	–	–

Notes: Italic type denotes significant factor loadings > |0.5| (Hair *et al.*, 2018). All factor correlations significantly differed from unity (i.e. the 95% confidence interval did not contain unity)

unlike Study 1a that used emotion words, Study 1b used the same items to measure participants' associations with emotional images.

Method

Participants. Similar to the (convenience) sampling procedure in Study 1, 33 German-speaking respondents (23 females) between 21 and 71 years of age (M = 29.39, SD = 11.12) participated in an online survey in exchange for the chance of winning a cash prize.

Procedure and materials. This study aimed to include one visual stimulus for each of the emotions tested in Study 1 to mirror the variety of emotions through a visual approach. In a pretest, ten respondents assigned an extensive set of 144 different pictures compiled via an online search to one of the 17 emotions they associated with the picture the most. Afterwards, they ranked the assigned pictures from the lowest to highest degree of association with the particular emotion. Eventually, 12 emotions could be unambiguously evoked by respective pictures (disgust, fear, anger, worry, sadness, envy, romantic love, love, joy, excitement, surprise and pride; see Appendix 2 for the picture stimuli and Appendix 3 for the full phrasing of the questions). These emotions cover the continua of the established emotional dimensions, valence, arousal and dominance (Fontaine *et al.*, 2007) and, hence, represent the latent emotional dimension factor structure in this data set.

The participants saw a portfolio of the 12 photography stimuli which were arranged in a randomized order. Respondents evaluated emotions evoked by the respective pictures [2]. Next, the 13 items representing the PAD dimensions and the emotional temperature dimension were assessed on a seven-point bipolar adjective scale (−3 to +3) in the spirit of the semantic differential (Osgood *et al.*, 1957; Table 5).

Results and discussion

The same EFA procedure as in Study 1a was adopted for Study 1b. Based on the goodness of fit measures of different alternative factor solutions (displayed in Table 3), a four-factor solution resulted as the most parsimonious model with acceptable fit indices. The rotated standardized factor loadings (significant and loading $>|0.5|$ on a factor; Table 5) permitted a straightforward factor interpretation comparable to the factor structure in Study 1a. Specifically, the simple structure solution indicated a valence, an arousal and a dominance dimension. Importantly, as expected, the fourth factor, emotional temperature, had high loadings for the items emotionally cold/emotionally warm, coldhearted/warmhearted and not touching/touching (see Table 5 for factor correlations). The factor loading matrix in Study 1b, therefore, suggests a comparable factor structure as in Study 1a.

Overall, Study 1 provides preliminary indication of emotional temperature as an emotional dimension distinct from other, established dimensions of emotions. While no single method is perfect and, for example, for the visual assessment approach, the type of motive of the tested visuals may moderate their effects on respondents (e.g. humans vs no humans; characteristics of the depicted humans such as age or gender), the fact that emotional temperature emerges as a dimension in both, the semantic as well as the visual study approach, provides initial evidence of the robustness of the results. The multi-method approach served to show that emotional temperature emerges as a dimension, regardless of whether emotions are triggered by words (involving more cognitive efforts of the respondents) or visuals (triggering the more immediately reactive brain system, Winkielman and Gogolushko, 2018). In the following, Study 2 serves to further demonstrate the robustness of the findings and the validity of the dimension vis-a-vis the evolutionary perspective.

Table 5. Standardized oblimin factor loading matrix and factor correlations (Study 1b)

Factor loadings/ correlations	Item/factor	Factor 1 (Temperature)				Factor 2 (Valence)				Factor 3 (Dominance)				Factor 4 (Arousal)			
		Est.	*SE*	*Est./SE*	*p-value*	*Est.*	*SE*	*Est./SE*	*p-value*	*Est.*	*SE*	*Est./SE*	*p-value*	*Est.*	*SE*	*Est./SE*	*p-value*
Factor loadings	Not touching/ touching	*0.832*	*0.031*	*26.826*	*0.000*	−0.142	0.029	−4.897	0.000	0.012	0.033	0.373	0.710	−0.066	0.034	−1.913	0.056
	Coldhearted/ warmhearted	*0.740*	*0.076*	*9.776*	*0.000*	0.250	0.084	2.980	0.003	−0.023	0.031	−0.744	0.457	0.039	0.031	1.247	0.212
	Cold/warm	*0.670*	*0.070*	*9.629*	*0.000*	0.273	0.076	3.578	0.000	0.043	0.034	1.258	0.208	−0.015	0.036	−0.415	0.678
	Negative/ positive	0.001	0.024	0.055	0.956	*0.969*	*0.020*	*48.478*	*0.000*	−0.020	0.019	−1.046	0.295	0.013	0.019	0.704	0.481
	Unpleasant/ pleasant	0.034	0.026	1.299	0.194	*0.924*	*0.023*	*40.875*	*0.000*	0.024	0.021	1.133	0.257	−0.023	0.023	−1.028	0.304
	Miserable/ delightful	0.052	0.033	1.555	0.120	*0.879*	*0.029*	*30.567*	*0.000*	0.030	0.026	1.138	0.255	−0.028	0.025	−1.113	0.266
	Bad/good	0.057	0.035	1.617	0.106	*0.873*	*0.030*	*28.978*	*0.000*	0.018	0.027	0.667	0.505	0.008	0.027	0.295	0.768
	Weak/strong	0.105	0.045	2.320	0.020	−0.091	0.035	−2.623	0.009	*0.828*	*0.045*	*18.479*	*0.000*	0.005	0.042	0.112	0.911
	Powerless/ powerful	−0.086	0.036	−2.400	0.016	0.182	0.058	3.134	0.002	*0.811*	*0.059*	*13.782*	*0.000*	−0.011	0.040	−0.265	0.791
	Submissive/ dominant	0.001	0.069	0.018	0.986	−0.121	0.065	−1.865	0.062	*0.562*	*0.061*	*9.150*	*0.000*	0.224	0.064	3.500	0.000
	Calm/excited	0.039	0.034	1.161	0.246	−0.028	0.034	−0.822	0.411	0.116	0.074	1.576	0.115	*0.857*	*0.073*	*11.755*	*0.000*
	Relaxed/ stimulated	−0.078	0.059	−1.331	0.183	−0.034	0.043	−0.776	0.438	−0.152	0.029	−5.316	0.000	*0.792*	*0.057*	*13.913*	*0.000*
	Inactive/active	−0.057	0.062	−0.923	0.356	0.217	0.060	3.642	0.000	0.334	0.059	5.638	0.000	0.467	0.058	8.128	0.000
Factor correlations	Factor 1	1	–	–	–												
	Factor 2	0.733	0.041	17.709	0.000	1	–	–	–								
	Factor 3	0.175	0.049	3.545	0.000	0.393	0.043	9.054	0.000	1	–	–	–				
	Factor 4	−0.293	0.048	−6.076	0.000	−0.037	0.050	−0.742	0.458	0.497	0.047	10.642	0.000	1	–	–	–

Notes: Italic type denotes significant factor loadings > |0.5| (Hair *et al.*, 2018). All factor correlations significantly differed from unity (i.e. the 95% confidence interval did not contain unity)

Study 2: Confirming and validating the dimensionality of "emotional temperature"

Designed as the main study of this research, Study 2 aims to confirm the detected four-factor structure comprising the three PAD dimensions and emotional temperature as a distinct emotional dimension, using comprehensive panel data. Crucially, in line with the literature documenting differences between positive and negative emotions for PAD dimensions, such as dominance because of the evolutionary-driven negativity bias (Baumeister *et al.*, 2001; Rozin and Royzman, 2001), the extensive data set underlying this study enables a focused observation of the role of emotional temperature within positive and negative emotions. From an evolutionary perspective, those types of emotions served fundamentally different functions, such as dealing with threats versus dealing with opportunities (Griskevicius *et al.*, 2009). Specifically, as positive emotions (such as love or happiness) generally enhance reproduction success and negative emotions (such as fear or disgust) generally increase survival success, the dimensional structures within those emotional groups may also differ. Therefore, the dimensions of emotions are assessed by separately investigating emotional temperature relative to the other dimensions of emotions and testing for invariance across positive and negative emotions.

Using a semantic approach, this study reconfirms the factor structure for both positive and negative emotions, followed by the formal invariance testing across the groups. Further, Study 2 serves to assess reliability as well as construct validity of the emotional temperature dimension. The findings are illustrated via "temperature maps" which visualize the contrasts between emotional temperature and the previously introduced dimension of emotions of valence. Finally, Study 2 examines the proposed relation of emotional temperature with social proximity for both, positive and negative emotions.

Method

Sample selection. The sample of respondents was recruited via Prolific, a subject tool for online experiments (Palan and Schitter, 2018; average Prolific quality score = 99.1). The sample size was determined before any data analysis and the study received full ethics approval before the data collection at a North American University. In exchange for a monetary compensation, participants living in the USA were invited to take part in the online survey using Prolific's representative samples tool which bases on census data from the US Census Bureau to divide the sample into subgroups with the same proportions as the national population (Prolific, 2021). In total, 317 respondents (157 females) between 18 and 78 years of age ($M = 45.50$, $SD = 16.21$) participated in the study.

Procedure and materials. Participants saw a list of 17 emotion words. These were presented in a randomized order across respondents. The emotion words in Study 2 were selected based on the following criteria:

- they had to be relevant in marketing context (e.g. in advertisement); and
- cover a variety of both positive and negative emotions to allow for a focused look at the relations of the emotional temperature dimension with valence within these two emotion groups.

Thus, the baseline for the selection of emotion words were "The Big Six" by Ekman *et al.* (1969), namely, happiness, sadness, anger, disgust, fear and surprise. These were complemented by emotions from Ekman's expanded list of basic emotions (Ekman, 1999), specifically contempt, contentment, embarrassment, excitement, guilt, pride in achievement and shame. Finally, additional emotions relevant to marketing consumption settings were

added as well, that is, envy, loneliness, love and worry (Richins, 1997). See Table 6 for a full overview of included emotion terms.

Similar to the approach in Study 1a, for each emotion word, participants indicated the level of association with 13 items on a seven-point bipolar adjective scale (−3 to +3). The 13 items consisted of four items for the established dimension of valence (unpleasant/pleasant; bad/good; negative/positive; and miserable/delightful), three items for the established dimension of dominance (submissive/dominant; weak/strong; and powerless/powerful) and two items for arousal (relaxed/stimulated; and inactive/active). Similar to Study 1a, the PAD semantic differential measures of emotional state were adapted for the items on the established dimensions (Mehrabian and Russell, 1974; Russell and Mehrabian, 1977). Like in Study 1, the items for the emotional temperature dimension were based on the literature on emotional warmth, also accounting for potential cultural and language differences in interpreting some of the anchor points (i.e. emotionally cold/emotionally warm; cool/warm; cold/hot; and not touching/touching; see Appendix 1 for the correlation matrix of the scale items and Appendix 3 for the full phrasing of the questions).

Manipulation check. The list of emotion words was composed with the goal of reflecting a multitude of both positive or negative emotions. To conduct subsequent separate analyses for the positive and negative emotions group, the data set was split based on the arithmetic mean of the items designed to assess valence. Emotions with a valence mean greater than 3.5 (the scale midpoint) were interpreted as belonging to the positive emotions group. Emotions with a valence mean below or equal to 3.5 were identified as negative emotions. As intended, the six emotions included to serve as positive emotions showed valence means greater than 3.5. The rest of the emotions showed valence means below 3.5 and, consequently, could be treated as negative emotions (see Table 6 for an overview of the emotions grouped into the positive and negative emotions group).

Table 6.
Means and standard deviations of the emotional dimension items for each emotion (Study 2)

		Valence		Emotional temperature		Arousal		Dominance	
Emotion group	Emotion	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Positive emotions	Pride	6.314	0.865	5.401	1.070	6.010	1.006	6.062	0.873
	Happiness	6.691	0.582	6.145	0.752	5.697	1.152	5.517	0.929
	Love	6.593	0.704	6.521	0.647	5.844	1.146	5.566	1.049
	Surprise	4.934	1.320	4.875	1.138	5.740	1.034	4.578	1.191
	Excitement	6.127	0.922	5.756	0.902	6.306	0.851	5.640	0.970
	Contentment	6.132	1.218	5.574	1.076	4.423	1.491	5.037	1.109
Negative emotions	Envy	2.150	1.202	2.653	1.313	4.368	1.217	3.209	1.288
	Loneliness	2.122	1.258	2.256	1.214	3.109	1.088	2.734	1.282
	Embarrassment	2.024	1.127	2.963	1.290	4.192	1.157	2.510	1.195
	Disgust	1.787	1.072	2.226	1.215	4.278	1.384	3.672	1.357
	Anger	1.859	1.090	3.010	1.604	5.178	1.629	4.495	1.748
	Guilt	1.791	1.032	2.553	1.268	3.787	1.244	2.595	1.230
	Contempt	2.178	1.418	2.359	1.400	4.382	1.441	4.080	1.558
	Fear	1.840	1.072	2.606	1.360	4.700	1.666	2.620	1.400
	Sadness	1.870	1.065	2.680	1.464	3.308	1.181	2.500	1.172
	Shame	1.708	1.045	2.390	1.241	3.664	1.245	2.274	1.234
	Worry	2.152	1.160	3.215	1.391	4.257	1.418	2.749	1.270

Note: Aritmethic means of items predicted to load on the respective emotional dimension factors

Results and discussion

Exploratory factor analysis. For the positive and negative emotions groups, an EFA was conducted on the 13 bipolar adjective scales across all observations and participants. The purpose of the EFA was to observe, whether emotional temperature results as an individual factor underlying the items, separate from the established emotional dimensions The statistical software package SPSS served to conduct the EFA, using Promax rotation and principal axis factoring. Similar to Study 1, an oblique rotation technique was used, as it was expected that emotional temperature was likely to correlate to a certain degree with the PAD emotional dimensions, particularly valence (Hair *et al.*, 2018).

The Kaiser–Meyer–Olkin statistic or measure of sampling adequacy (MSA) for both the positive ($MSA_{Positive}$ = 0.925) and the negative emotions group ($MSA_{Negative}$ = 0.905) indicates "marvelous" adequacy of the correlations (Kaiser, 1974) and Bartlett's test of sphericity is significant for both groups. The percentage of variance criterion was chosen to determine the number of extracted factors instead of the latent root criterion (Kaiser rule), as the latter has the tendency to extract a too conservative number of factors for small numbers of variables (Fabrigar *et al.*, 1999; Hair *et al.*, 2018). The percentage of variance criterion indicated a four-factor solution, as the fourth factor still accounts for a sizeable percentage of the variance (above the recommended percentage of 5%; Hair *et al.*, 2018; Table 7). Scree plots (Figure 1) confirmed the four-factor solution, with the four factors accounting for 79.49% of the total variance in the positive emotions groups and 78.20% in the negative group (Table 7).

Table 8 displays the rotated factor loadings. The factor loading matrix revealed a simple structure solution without substantial cross-loadings, which resulted in a straightforward factor interpretation. As expected, emotional temperature emerged as a latent factor distinct from valence and was defined by the items emotionally cold/emotionally warm, cool/warm, cold/hot and not touching/touching. The other three factors reflect the established emotional dimensions of valence, arousal and dominance, overall providing high face validity. Table 9 reports the internal consistency reliability of the extracted factors via Cronbach's alpha with scores above the lower limit of acceptability of 0.6 (Hair *et al.*, 2018). Consequently, internal consistency of the individual factors is established.

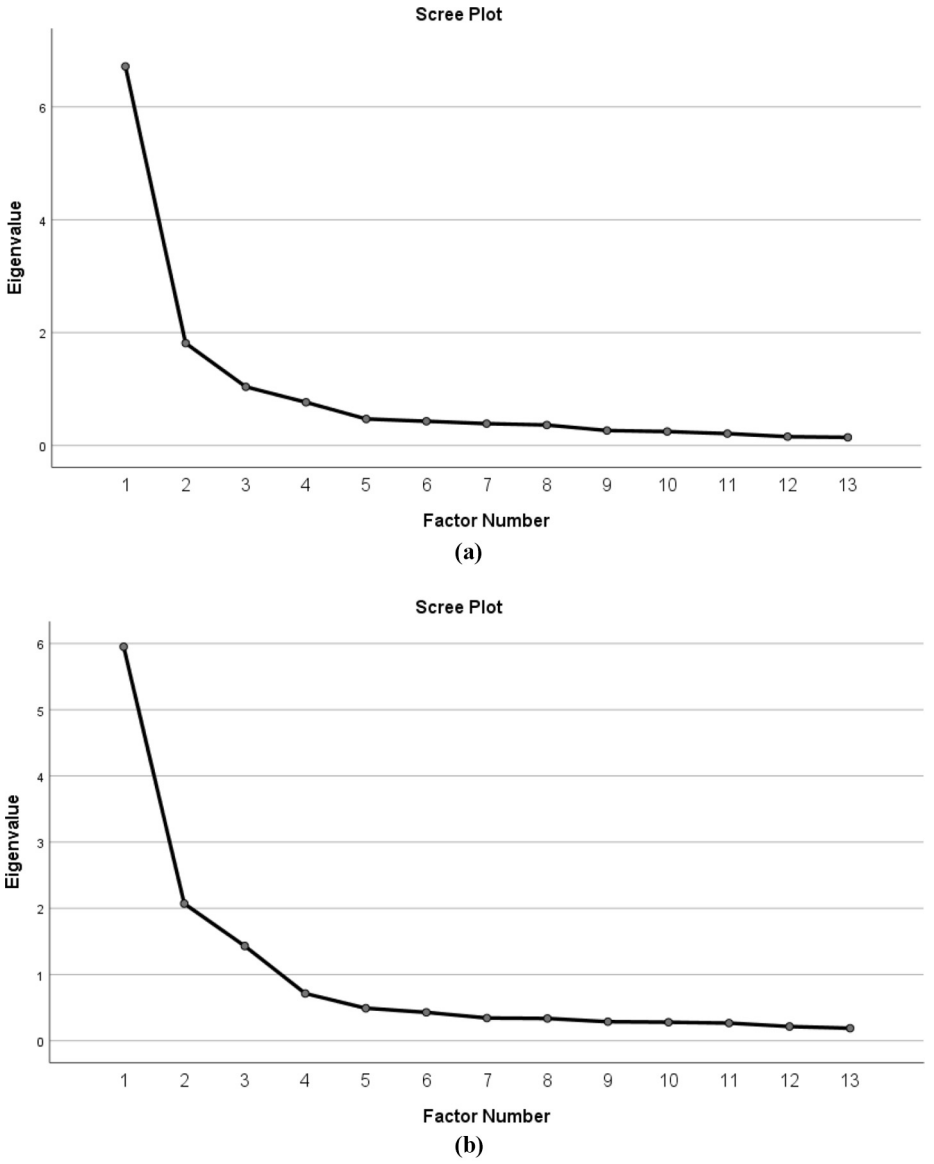
To show that emotional temperature is an emotional dimension distinct from the other established emotional dimensions, the discriminant validity was assessed through the factor correlations (displayed in Table 8). Consistent with Studies 1a and 1b, emotional temperature (Factor 2) correlates the highest with valence (Factor 1) in the positive emotions group (corr = 0.730). This correlation is remarkably lower in the negative emotions group (corr = 0.597). Correlations of the emotional temperature dimension with the other emotional dimensions range from 0.279 (with arousal in the positive emotions group) to 0.533 (with dominance in the positive emotions group). Interestingly, overall, correlations of emotional temperature with the other established dimensions appear to be lower in the negative (vs positive) emotions group. While the results confirm that emotional temperature consistently emerges as a distinct factor in both groups, it also reveals interesting additional insights suggesting that particularly for negative emotions, emotional temperature is even more distinct from all the previously established emotional dimensions.

In sum, using a sample from a different country, the results of the EFA confirm the factor structure detected in Study 1 and show the external validity of the dimension of emotional temperature as well as its discriminant validity through the distinction between the valence dimension and the emotional temperature dimension.

Table 7.
Total variance explained in the four-factor solution of the exploratory factor analysis (Study 2)

Emotion group	Factor	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings
		Total	% of variance	Cumulative (%)	Total	% of variance	Cumulative (%)	Total
Positive emotions	1	6.717	51.666	51.666	6.456	49.660	49.660	5.713
	2	1.814	13.952	65.617	1.442	11.095	60.755	5.126
	3	1.039	7.992	73.609	0.711	5.472	66.228	4.280
	4	0.765	5.885	79.494	0.411	3.163	69.390	1.966
Negative emotions	1	5.951	45.779	45.779	5.658	43.525	43.525	4.768
	2	2.071	15.933	61.712	1.723	13.256	56.781	4.046
	3	1.431	11.004	72.716	1.117	8.590	65.371	3.765
	4	0.713	5.485	78.201	0.316	2.428	67.800	2.243

Note: Extraction method: principal axis factoring



Notes: (a) Positive emotions group; (b) Negative emotions group

Figure 1.
Scree plots for the positive and negative emotions group (Study 2)

Confirmatory factor analysis. While the EFA reveals that emotional temperature emerges as an emotional dimension distinct from the established emotional dimensions, a CFA validates the factor structure, as depicted in Figure 2.

As conceptualized and confirmed by the EFA, the corresponding items were specified for the CFA: a latent construct of emotional temperature (cool/warm; cold/hot; not touching/

Table 8.
Pattern matrices of the rotated factor loadings for the positive and negative emotions group (Study 2)

Factor loadings/ correlations	Item/factor	Positive emotions 1	2	3	4	Negative emotions 1	2	3	4
Factor loadings	Bad/good	*0.941*	−0.054	0.036	−0.009	*0.882*	0.017	−0.025	−0.003
	Negative/ positive	*0.907*	0.000	0.009	−0.004	*0.890*	0.013	−0.009	0.000
	Unpleasant/ pleasant	*0.906*	0.036	−0.009	−0.035	*0.893*	−0.013	0.020	−0.044
	Miserable/ delightful	*0.836*	0.070	−0.042	0.095	*0.799*	−0.024	0.105	−0.007
	Cool/ warm	0.081	*0.837*	−0.038	−0.057	−0.091	*0.914*	0.096	−0.087
	Cold/ hot	−0.143	*0.742*	0.054	0.132	−0.084	*0.778*	0.063	0.081
	Not touching/ touching	0.042	*0.723*	0.051	−0.042	0.154	*0.757*	−0.104	0.030
	Emotionally cold/ warm	0.278	*0.690*	−0.081	−0.032	0.358	0.476	−0.110	0.019
	Powerless/ powerful	0.042	0.016	*0.893*	−0.083	0.046	−0.011	*0.880*	−0.052
	Weak/ strong	0.139	0.060	*0.718*	−0.034	0.033	0.067	*0.821*	−0.040
	Submissive/ dominant	−0.113	−0.052	*0.670*	0.120	−0.034	−0.027	*0.756*	0.094
	Relaxed/ stimulated	−0.015	−0.017	−0.052	*0.792*	−0.110	0.024	−0.023	*0.688*
	Inactive/ active	0.094	0.060	0.218	*0.572*	0.114	−0.016	0.189	*0.638*
Factor correlations	Factor 1	1.000	0.730	0.589	0.177	1.000	0.597	0.489	0.156
	Factor 2		1.000	0.533	0.279		1.000	0.382	0.373
	Factor 3			1.000	0.543			1.000	0.615
	Factor 4				1.000				1.000

Note: Italic type denotes factor loadings > |0.5| (Hair *et al.*, 2018)

Table 9.
Internal consistency reliability of the factors (Cronbach's alpha) for the positive and negative emotions group (Study 2)

Emotion group	Construct	No. of items	Cronbach's alpha
Positive emotions	Emotional temperature	4	0.869
	Valence	4	0.949
	Arousal	2	0.675
	Dominance	3	0.813
Negative emotions	Emotional temperature	4	0.858
	Valence	4	0.928
	Arousal	2	0.652
	Dominance	3	0.868

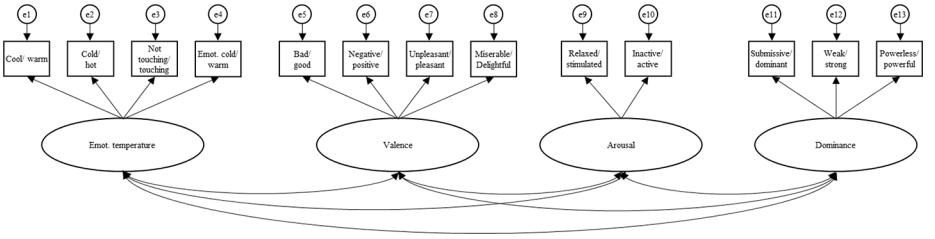


Figure 2.
Path diagram showing measurement model specification (confirmatory factor analysis model) (Study 2)

touching; and emotionally cold/warm), valence (bad/good; negative/positive; unpleasant/pleasant; and miserable/delightful), arousal (relaxed/stimulated; and inactive/active) and dominance (submissive/dominant; weak/strong; and powerless/powerful), each. To enable the invariance testing, CFAs were conducted both for the positive and negative emotions

groups, via the statistical software package AMOS 26, using the maximum likelihood estimation procedure (Hair *et al.*, 2018).

Table 10 reports the results of the CFA. The overall model chi-square values are significant and the normed chi-square values (i.e. chi-square/df) are above the recommended threshold of 5 (Hair *et al.*, 2018). However, chi-square as a goodness-of-fit measure is heavily influenced by sample size, so that it is recommended to consider additional absolute and

Validity, reliability, and CFA scores	Positive emotions				Negative emotions			
Overall model fit								
χ^2	597.356 (df = 59; p = 0.000)				1,181.119 (df = 59; p = 0.000)			
χ^2/df	10.125				20.019			
Tucker–Lewis Index (TLI)	0.960				0.948			
Comparative Fit Index (CFI)	0.970				0.961			
Normed Fit Index (NFI)	0.967				0.959			
Incremental Fit Index (IFI)	0.970				0.961			
Relative Fit Index (RFI)	0.956				0.946			
RMSEA	0.069				0.074			
Standardized regression weights and factor validity/ reliability								
Factor 1: Valence								
CR	0.950				0.929			
AVE (Square root of AVE)	0.825 (0.908)				0.765 (0.875)			
Bad/good	0.919				0.879			
Negative/ positive	0.911				0.895			
Unpleasant/ pleasant	0.921				0.886			
Miserable/ delightful	0.882				0.837			
Factor 2: Emotional temperature								
CR	0.874				0.867			
AVE (Square root of AVE)	0.637 (0.798)				0.621 (0.788)			
Cool/ warm	0.849				0.830			
Cold/ hot	0.682				0.783			
Not touching/ touching	0.760				0.680			
Emotionally cold/ warm	0.885				0.848			
Factor 3: Dominance								
CR	0.820				0.869			
AVE (Square root of AVE)	0.608 (0.780)				0.689 (0.830)			
Powerless/ powerful	0.860				0.862			
Weak/ strong	0.852				0.848			
Submissive/ dominant	0.599				0.777			
Factor 4: Arousal								
CR	0.763				0.743			
AVE (Square root of AVE)	0.638 (0.799)				0.618 (0.786)			
Relaxed/ stimulated	0.531				0.490			
Inactive/ active	0.997				0.998			
Interconstruct correlations								
	F1	F2	F3	F4	F1	F2	F3	F4
F1	1.000				1.000			
F2	0.787	1.000			0.630	1.000		
F3	0.660	0.586	1.000		0.523	0.418	1.000	
F4	0.372	0.387	0.605	1.000	0.291	0.370	0.631	1.000

Table 10.
Reliability, validity and confirmatory factor analysis scores for the positive and negative emotion group (Study 2)

incremental fit indices to evaluate model fit. The goodness-of-fit criteria with the Tucker–Lewis Index (TLI), the Comparative Fit Index (CFI), the Normed Fit Index (NFI) and the Relative Fit Index (RFI), as well as the Incremental Fit Index (IFI), are all higher than the threshold of 0.9 (Hair *et al.*, 2018), for both groups. The RMSEA for both emotion groups is below the threshold of 0.08 (Byrne, 2001; Hair *et al.*, 2018). Thus, the CFA results suggest that the measurement model containing emotional temperature as a separate emotional dimension provides a good fit.

Next, construct validity is assessed, that is, convergent, discriminant and nomological validity. First, to determine *convergent validity*, the (unstandardized) factor loadings are evaluated. All loading estimates are statistically significant ($p < 0.001$), as required for convergent validity, and are above the rule of thumb of |0.50| (Hair *et al.*, 2018). Scores for the average variance extracted (AVE) and construct reliabilities were calculated using the "stats tool package" by Gaskin (2016). The AVE is above the ≥ 0.5 cutoff, ranging from 0.608 (for dominance) to 0.825 (for valence) in the positive emotions group and from 0.618 (for arousal) to 0.765 (for valence) in the negative emotions group (Table 10). Construct reliabilities (CRs) also exceed the adequate reliability value of 0.7 for all factors in both emotion groups. Hence, evidence supports the convergent validity of the measurement model.

As this research aims to uncover emotional temperature as a distinct dimension to the previously established emotional dimensions, *discriminant validity*, focusing on the degree to which concepts are indeed distinct is of particular relevance. Discriminant validity of the factors in the model is detected, if the square roots of the AVE scores are greater than the corresponding interconstruct correlations estimates. As Table 10 indicates, in both emotion groups, the square root AVE values are greater than the correlation between the factors, thus confirming discriminant validity. In other words, the results provide evidence that the sets of measures for the individual emotional dimensions are discriminated from each other, and importantly, emotional temperature is distinct from the previously established dimensions.

Finally, to assess *nomological validity*, correlations of the established emotional dimensions of valence, arousal and dominance are compared to previously assessed relations of these three dimensions. Mehrabian and Russell (1974) find that among the PAD dimensions, arousal and dominance correlate the strongest. The CFA results of this study also reveal that this specific correlation across both negative and positive emotions is the strongest among the relations of the previously established dimensions.

Temperature maps. To further illustrate the association of the individual emotion words with the emotional temperature dimension, z-standardized factor scores for all four dimensions extracted from the CFA for both the positive and negative emotions group served to map out the emotional dimensions in a multidimensional space, exemplarily for the relation of emotional temperature and valence (Figure 3).

The positions of the emotion words on the valence dimension are in general consistent with existing emotion literature (Fontaine *et al.*, 2007; Solomon and Stone, 2002). Happiness is the most positive emotion (highest scores on the valence dimension), while disgust and shame are the most negative ones. At the same time, consistent with this paper's theorizing, among positively valenced emotions, those linked to close human relationships (e.g. love) are much warmer than those linked to expressing social distance in relationships (e.g. pride). Surprise scores the lowest on valence among the emotions classified as positive. This is consistent with the ambivalent nature of the surprise emotion, that is, it can be either pleasant or unpleasant (Noordewier and Breugelmans, 2013). Further, unlike love that depends on close relationships with others, surprise depends on situational factors and reflects a response to an unexpected event, such as unexpected sounds (Ekman *et al.*, 1983).

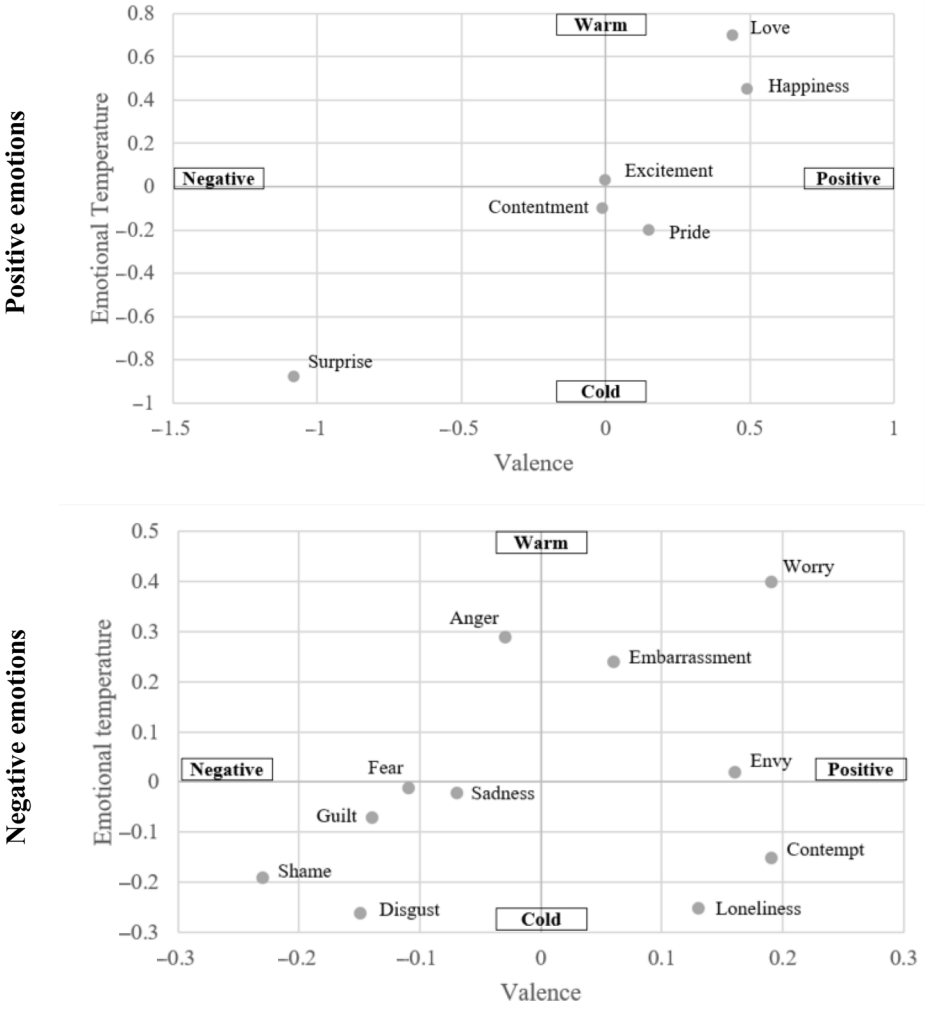


Figure 3.
Temperature maps for the relation of emotional temperature and valence (Study 2)

In reaction to surprise, individuals may experience a burst of adrenaline that helps prepare the body to either fight or flee (Mobbs *et al.*, 2015). Such triggered fight or flight responses increase the social distance to others which may explain why surprise emerges as rather cold on the emotional temperature dimension. This finding further highlights the importance of accounting for the evolutionary functions of individual emotions in understanding their dimensionality. For negatively valenced emotions, while very similar in valence, those connected to close relationships (e.g. worry) are much warmer than those related to social distance (e.g. loneliness). Unsurprisingly, overall, love is the warmest emotion and disgust and loneliness are the coldest. In sum, these results confirm the face validity of the dimension of emotional temperature and show its discriminant validity through its differentiation from established emotional dimensions.

Invariance testing of positive and negative emotions. The results so far have indicated that positive and negative emotions behave differently in terms of the underlying emotional temperature dimension. To assess, to which extend the proposed model in Figure 2 is comparable across positive and negative emotions, model invariance is tested between the two emotion groups. The base of the process is a series of empirical comparisons of models with increasingly restrictive constraints (Hair *et al.*, 2018). Specifically, we conducted CFA by analyzing the two emotion groups simultaneously, but estimating four different models (reported in Table 11). First, a totally free multiple group model estimates all free parameters (e.g. factor loadings) separately. Namely, while the general four-factor structure including emotional temperature holds across groups, the items are allowed to load differently onto the respective factors across positive and negative emotions. This model resulted in good fit measures (RMSEA = 0.051; CFI = 0.964), establishing *configural variance*. Hence, the general four-factor structure including emotional temperature holds across the two groups, consistent with Study 1. In other words, the general model structure depicted in Figure 2 exists in both emotions groups and the first stage of invariance testing assessing whether the constructs are congeneric across groups is established.

The next stages of invariance testing consist of *metric invariance*, representing equivalence in the relationships between the measured variables and constructs, *factor covariance invariance*, testing whether constructs relate to each other in a similar fashion across groups, and *error variance invariance*, assessing whether the measurement error variance in the indicators is equivalent among groups. The chi-square difference is used to evaluate, whether this more constrained model fits as well as a less constrained model. Table 11 contains the model fit statistics for each model and the chi-square difference test for each model comparison.

The patterns observed across these models suggest that when imposing increasingly restrictive constraints onto the model, model fit significantly decreases ($p < 0.001$). The most restrictive model testing for error variance invariance, finally, imposes equivalence in the relationships between the measured variables and constructs, between the constructs themselves and in the measurement error variance in the indicators. Goodness-of-fit indices indicate a substantially lower model fit, compared to the totally free multiple group model (RMSEA = 0.069; and CFI = 0.916). The results suggest that some items are more/less important for one group than for the other (Campbell *et al.*, 2008).

Thus, overall, the results indicate that while, importantly, the same factor structure including emotional temperature underlies both emotions groups, the items loading onto the factors differ, supporting the approach in this study to further test emotional temperature within positive and negative emotions. Therefore, consistent with the evolutionary perspective, emotional temperature underlies both positive and negative emotions, but the items loading onto the factors differ slightly (Table 8).

Table 11. Measurement invariance test for the positive and negative emotion group (Study 2)

Model tested	Model fit measures					Model differences		
	χ^2	df	p	RMSEA	CFI	$\Delta\chi^2$	Δdf	p
Configural invariance	1,778.468	118	0.000	0.051	0.964			
Metric invariance	2,053.000	127	0.000	0.053	0.959	274.532	9	0.000
Factor covariance invariance	2,827.198	137	0.000	0.060	0.942	1,048.731	19	0.000
Error variance invariance	4,034.813	150	0.000	0.069	0.916	2,256.346	32	0.000

Criterion validity against social proximity. Criterion validity assesses the extent to which the proposed temperature dimension relates to other variable(s) which are expected to correlate with the temperature dimension. This research proposes that a major distinction of emotional temperature compared to the other established emotions is its reflection of human relationships and interactions. One of the closest established constructs related to those factors is the concept of social proximity (Bruno *et al.*, 2017). Hence, the emotional temperature dimension should correlate with social proximity. To test the relation of the emotional dimensions with social proximity, in addition to the items incorporated in the CFA, respondents evaluated additional items addressing the concept of social proximity. Namely, participants evaluated the emotion terms based on the items attack/protect, exclude/include, makes me move away from someone/makes me move towards someone and distance from others/closeness to others. These items were adopted from the literature on social proximity (Fischer and van Kleef, 2010; Fischer *et al.*, 2016). Internal consistency of the items was satisfactory, both in the positive emotions group (Cronbach's alpha = 0.887) and the negative emotions groups (Cronbach's alpha = 0.819). Z-standardized factor scores for all four dimensions were extracted from the CFA for both the positive and negative emotions group and were correlated with the z-standardized arithmetic mean of the items related to social proximity (Table 12).

In support of the criterion validity, in both emotions groups, social proximity correlates the strongest with emotional temperature ($corr_{pos.emot.} = 0.845$, $p < 0.001$; and $corr_{neg.emot.} = 0.720$, $p < 0.001$). Correlations of the established emotional dimensions with social proximity are considerably lower in most constellations (Table 12). Interestingly, emotional temperature correlates more strongly with social proximity in the positive emotions group compared to the negative emotions group, where valence almost relates as strongly to social proximity ($corr_{neg.emot.} = 0.694$). This is consistent with the idea that positive emotions are generally more helpful in enhancing reproduction success, where social proximity is paramount, whereas negative emotions are more related to survival success, where it is important to estimate potential danger coming from strangers; hence, those are more associated with valence.

General discussion

This research conceptualizes, measures and comprehensively validates the temperature dimension of emotions alongside the established dimensions of valence, arousal and dominance. Specifically, it conceptualizes emotional temperature as a bipolar dimension of an affective state that underlies human relationships, ranging from cold to warm, such that social closeness is linked to emotional warmth and social distance to emotional coldness.

Emotion group	Construct	Correlation with social proximity
Positive emotions	Emotional temperature	0.845
	Valence	0.713
	Arousal	0.337
	Dominance	0.552
Negative emotions	Emotional temperature	0.720
	Valence	0.694
	Arousal	0.255
	Dominance	0.358

Note: Correlations significant at the $p < 0.01$ level

Table 12. Correlation coefficients of the confirmatory factor analysis factor scores with social proximity (Study 2)

Using two different assessment approaches (semantic vs visual), this research shows that this new temperature dimension is correlated with, but separate from, established emotional dimensions. Face validity, discriminant and convergent validity, as well as the nomological and criterion validity of the emotional temperature dimension, are assessed.

Theoretical contributions

With respect to the academic contribution, fundamentally, this research proposes a novel lens to investigate the dimensionality of emotions. Specifically, while previous research, including PAD, was mostly concerned with understanding systematic differences between individual emotions by capturing and describing their affective states, this research paves the way to approach dimensions of emotions based on their functionality in solving recurrent adaptive problems related to survival and reproduction (Griskevicius *et al.*, 2009, 2010). Thus, this research demonstrates that the effects of different emotions depend on not only the affective state, captured by PAD, but also the underlying reflection of human interactions. While this research specifically looks at the relationships with other humans as the key underlying function of the emotions, emotions of course have other evolutionary functions that open avenues for future research.

Further, by introducing and validating temperature as a distinct and important dimension of emotions, this research connects disperse streams of literature on "warm" (Griskevicius *et al.*, 2010; Khoshghadam *et al.*, 2019) and "cold" (Duhachek *et al.*, 2012) emotions in a novel light and opens new avenues for research. Understanding the spectrum of emotional temperature and the relative positions of different emotions on this dimension has important theoretical implications; for example, in the domain of advertising and communication research (Dodds *et al.*, 2021; Poels and Dewitte, 2019) by revealing systematic differences in terms of temperature among emotions of the same valence (e.g. while love and pride are both positive emotions, they differ in emotional warmth). In a similar vein, emotional temperature can help explain differences among variants of the same emotion, such as within different types of pride (e.g. hubristic versus authentic pride, Decrop and Derbaix, 2010) or envy (benign versus malicious envy, van de Ven *et al.*, 2011).

Moreover, Study 2 uncovers subtle differences in the importance of emotional temperature within positive and negative emotions. These results are in line with the idea that emotional temperature can extend to situational factors that usually characterize those groups of emotions. In this way, the current research offers important implications for the emerging literature examining situational emotional warmth (Hadi and Block, 2019).

Finally, uncovering the emotional temperature dimension underlying human relationships contributes to the stream of literature on prosocial behavior (Holdershaw *et al.*, 2018; Melnyk *et al.*, 2022; White *et al.*, 2019) and may present new opportunities to use emotional warmth to enhance prosocial consumer behavior. For example, because appeals associated with human relationships, such as social norms are effective (Melnyk *et al.*, 2022), emotionally warm appeals may be an alternative way to enhance prosocial behavior by activating social closeness.

Practical implications

The findings have implications for marketing practice. First, this research introduces the emotional temperature map as an illustration of the unique contribution of this new dimension, which could help guide practitioners in their choice of emotional appeals. For example, the results enable marketing managers to look beyond valence and make informed decisions on which specific emotional appeals – emotionally cold versus warm – are likely to be effective in their communications or retail environments. For instance, in hot climates or

seasons, where previous research indicates that consumers respond better to emotionally cold stimuli (Bruno *et al.*, 2017) or in retail environments targeting luxury brands or status products (Hadi and Block, 2019), practitioners should consider cold emotions, such as envy or loneliness (from the negative spectrum of emotions) or pride (from the positive spectrum). In contrast, in cold climates, seasons or cold retail environments, warm emotions such as love should be preferred over other positive emotions and worry should be preferred over other negative emotions.

Second, the results suggest that emotional temperature can extend beyond individual emotions to images, situations and contexts. For example, Study 1b, where emotional temperature of visuals is measured, provides initial support for this idea. While the images were designed and pretested to evoke a specific dominant emotion, being images, they may naturally evoke more than one emotion. Yet, as Study 1b reveals the same dimensional structure as the studies using a semantic approach focusing on a single emotion, the results suggest that emotional temperature may exist for images. This creates opportunities for practitioners to design and pretest visual campaigns based on the desired emotional temperature.

Importantly, positive brand images and organizational reputations are greatly influenced by perceptions of warmth (Aaker *et al.*, 2010; Hess and Melnyk, 2016). However, until now, little has been understood about the variety of individual emotions that comprise emotional warmth. This research explains how discrete emotions – from love and happiness to worry and embarrassment – relate to warmth and, thereby, provides a deeper understanding of how warmth impacts consumers' affective states. This, in turn, provides a better foundation upon which to understand the effect of advertisements that invoke warmth or coldness. While such appeals be common in marketing campaigns, this research provides the first clear evidence that emotional temperature is a unique dimension of affect.

Limitations and future research implications

In this research, a rich portfolio of 17 basic emotions relevant in everyday contexts was examined. Future research could further refine the emotional temperature dimension by analyzing more complex emotions, such as regret, and their respective position on the temperature map.

Moreover, future research should further replicate the findings across a wider variety of respondents, because although there is strong evidence suggesting that basic emotions are pancultural (Russell, 1991) and we observe a similar factor structure including emotional temperature as a separate emotional dimension across two different cultures and countries (Germany vs the USA), associations related to specific emotions can differ across cultures (Fang *et al.*, 2019; Uchida and Kitayama, 2009). For instance, pride is one of the deadly sins in Christianity and is discouraged in Buddhism, but was a virtue in Greek ethics. Therefore, analyzing bivalent emotions such as pride and surprise as well as the effect of culture on the positions of emotions on the temperature dimension, and the role of social proximity (Tsarenko and Strizhakova, 2013), provides a promising avenue for future research.

Additionally, a dedicated look into gender and age differences in response to visual emotional stimuli appears to be interesting. For example, while some studies suggest that females outperform males in emotion recognition (Kret and De Gelder, 2012; McClure, 2000), others report no difference or an advantage for males in emotion processing (Grimshaw *et al.*, 2004; Voyer *et al.*, 2017). Similarly, the respondents' age could influence emotional processing (Olderbak *et al.*, 2019). Consequently, future studies could replicate the "visual approach" of this paper basing on a more extensive number of respondents and types of images to tease out the demographics effects as well as to address the effects of different

types of visuals (e.g. cartoon characters versus avatars versus real people, etc.) and their interaction with other marketing stimuli, such as background music (Klein *et al.*, 2021).

Finally, further research should address the relationship between emotional temperature and other underlying emotional appraisals such as uncertainty, legitimacy/fairness and goal consistency as well as its effect on marketing outcomes (Klein and Melnyk, 2016; Septianto, 2020).

In general, this paper sets the stage for additional work examining emotional temperature and its effects on consumer behavior.

Notes

1. For subsequent analyses in Studies 1 and 2, the bipolar adjectives scales were recoded to scales ranging from 1 to 7.
2. As manipulation check, respondents indicated via two dropdown menus, which emotion was evoked the strongest and the second strongest via the visual. The mean of the shares of correct attribution of the strongest emotion to the intended emotions was 77%; the mean of the shares of correct attribution of the second strongest emotion to the intended emotions was 87%. The reported results are for the full data set. Only including observations for which a) the intended emotion was indicated to be evoked the strongest per stimulus and b) the intended emotion was perceived to be evoked the strongest or second strongest results in a similar factor loading matrix for the four-factor solution and, hence, interpretation of the factors.

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Appendix 1

Table A1. Pearson correlation matrix of all final scale items (Study 1a)

Item	Emotionally cold/ emotionally warm	Coldhearted/ warmhearted	Not touching/ touching	Bad/ good	Negative/ positive	Unpleasant/ pleasant	Miserable/ delightful
Emotionally cold/emotionally warm	*1*	0.802**	0.587**	0.741**	0.734**	0.706**	0.711**
Coldhearted/warmhearted	*0.802***	*1*	0.606**	0.809**	0.805**	0.789**	0.794**
Not touching/touching	*0.587***	*0.606***	*1*	0.554**	0.566**	0.540**	0.538**
Bad/ good	0.741**	0.809**	0.554**	*1*	0.946**	0.923**	0.895**
Negative/positive	0.734**	0.805**	0.566**	*0.946***	*1*	0.931**	0.900**
Unpleasant/pleasant	0.706**	0.789**	0.540**	*0.923***	*0.931***	*1*	0.905**
Miserable/delightful	0.711**	0.794**	0.538**	*0.895***	*0.900***	*0.905***	*1*
Weak/Strong	0.481**	0.509**	0.438**	0.535**	0.525**	0.514**	0.528**
Powerless/powerful	0.456**	0.476**	0.376**	0.538**	0.531**	0.531**	0.558**
Submissive/ dominant	0.228**	0.271**	0.243**	0.302**	0.318**	0.311**	0.328**
Inactive/active	0.388**	0.383**	0.339**	0.412**	0.415**	0.410**	0.423**
Calm/excited	0.177**	0.101**	0.119**	0.125**	0.135**	0.119**	0.172**
Relaxed/stimulated	0.050	−0.010	0.086*	−0.068*	−0.063*	−0.079*	−0.047

Notes: **Significance at $p < 0.001$; *significance at $p < 0.05$. Italic type denotes variables with high loadings on the same factor in exploratory factor analysis

(*continued*)

Table A1.

Item	Weak/strong	Powerless/powerful	Submissive/dominant	Inactive/active	Calm/excited	Relaxed/stimulated
Emotionally cold/emotionally warm	0.481**	0.456**	0.228**	0.388**	0.177**	0.050
Coldhearted/warmhearted	0.509**	0.476**	0.271**	0.383**	0.101**	−0.010
Not touching/touching	0.438**	0.376**	0.243**	0.339**	0.119**	0.086*
Bad/ good	0.535**	0.538**	0.302**	0.412**	0.125**	−0.068*
Negative/positive	0.525**	0.531**	0.318**	0.415**	0.135**	−0.063*
Unpleasant/pleasant	0.514**	0.531**	0.311**	0.410**	0.119**	−0.079*
Miserable/delightful	0.528**	0.558**	0.328**	0.423**	0.172**	−0.047
Weak/Strong	*1*	0.735**	0.500**	0.625**	0.423**	0.202**
Powerless/powerful	*0.735***	*1*	0.519**	0.619**	0.471**	0.219**
Submissive/ dominant	*0.500***	*0.519***	*1*	0.492**	0.417**	0.226**
Inactive/active	*0.625***	*0.619***	*0.492***	*1*	0.550**	0.354**
Calm/excited	0.423**	0.471**	0.417**	0.550**	*1*	0.610**
Relaxed/stimulated	0.202**	0.219**	0.226**	0.354**	*0.610***	*1*

Table A2. Pearson correlation matrix of all final scale items (Study 1b)

Item	Not touching/ touching	Coldhearted/ warmhearted	Emotionally cold/emotionally warm	Negative/ positive	Unpleasant/ pleasant	Miserable/ delightful	Bad/ good
Not touching/touching	*1*	0.640**	0.645**	0.441**	0.476**	0.447**	0.449**
Coldhearted/warmhearted	*0.640***	*1*	0.848**	0.751**	0.763**	0.758**	0.743**
Emotionally cold/emotionally warm	*0.645***	*0.848***	*1*	0.765**	0.764**	0.747**	0.755**
Negative/positive	0.441**	0.751**	0.765**	*1*	0.922**	0.896**	0.895**
Unpleasant/pleasant	0.476**	0.763**	0.764**	*0.922***	*1*	0.895**	0.901**
Miserable/ delightful	0.447**	0.758**	0.747**	*0.896***	*0.895***	*1*	0.861**
Bad/good	0.449**	0.743**	0.755**	*0.895***	*0.901***	*0.861***	*1*
Weak/strong	0.099*	0.223**	0.207**	0.293**	0.309**	0.295**	0.277**
Powerless/ powerful	0.089	0.242**	0.279**	0.415**	0.413**	0.410**	0.413**
Submissive/ dominant	−0.051	−0.028	0.002	0.074	0.092	0.092	0.087
Calm/ excited	−0.227**	−0.127*	−0.141**	0.014	0.004	−0.014	0.015
Relaxed/ stimulated	−0.309**	−0.295**	−0.293**	−0.164*	−0.211**	−0.183**	−0.172*

Notes: **Significance at $p < 0.001$; *significance at $p < 0.05$. Italic type denotes variables with high loadings on the same factor in exploratory factor analysis

(*continued*)

Table A2.

Item	Weak/strong	Powerless/powerful	Submissive/dominant	Calm/excited	Relaxed/stimulated	Inactive/ active
Not touching/touching	0.099*	0.089	−0.051	−0.227**	−0.309**	−0.067
Coldhearted/warmhearted	0.223**	0.242**	−0.028	−0.127*	−0.295**	0.082
Emotionally cold/emotionally warm	0.207**	0.279**	0.002	−0.141*	−0.293**	0.123*
Negative/positive	0.293**	0.415**	0.074	0.014	−0.164*	0.267**
Unpleasant/pleasant	0.309**	0.413**	0.092	0.004	−0.211**	0.263**
Miserable/ delightful	0.295**	0.410**	0.092	−0.014	−0.183**	0.249**
Bad/good	0.277**	0.413**	0.087	0.015	−0.172*	0.258**
Weak/strong	*1*	0.698**	0.498**	0.433**	0.144*	0.522**
Powerless/ powerful	*0.698***	*1*	0.524**	0.439**	0.184**	0.584**
Submissive/ dominant	*0.498***	*0.524***	*1*	0.517**	0.287**	0.477**
Calm/ excited	0.433**	0.439**	0.517**	*1*	0.649**	0.625**
Relaxed/ stimulated	0.144*	0.184**	0.287**	*0.649***	*1*	0.423**

Table A3. Pearson correlation matrix of all final scale items for the positive emotions groups (Study 2)

Item	Emotionally cold/ emotionally warm	Cool/warm	Cold/hot	Not touching/ touching	Bad/good	Negative/ positive	Unpleasant/ pleasant
Emotionally cold/ emotionally warm	*1*	0.747**	0.551**	0.654**	0.647**	0.672**	0.677**
Cool/ warm	*0.747***	*1*	0.592**	0.653**	0.600**	0.600**	0.610**
Cold/hot	*0.551***	*0.592***	*1*	0.547**	0.394**	0.423**	0.430**
Not touching/ touching	*0.654***	*0.653***	*0.547***	*1*	0.535**	0.525**	0.557**
Bad/good	0.647**	0.600**	0.394**	0.535**	*1*	0.847**	0.847**
Negative/positive	0.672**	0.600**	0.423**	0.525**	*0.847***	*1*	0.836**
Unpleasant/pleasant	0.677**	0.610**	0.430**	0.557**	*0.847***	*0.836***	*1*
Miserable/delightful	0.661**	0.605**	0.438**	0.562**	*0.803***	*0.794***	*0.819***
Relaxed/ stimulated	0.086**	0.090**	0.234**	0.103**	0.078**	0.074**	0.050*
Inactive/active	0.312**	0.300**	0.372**	0.314**	0.337**	0.336**	0.311**
Submissive/dominant	0.177**	0.191**	0.252**	0.208**	0.259**	0.238**	0.239**
Weak/strong	0.469**	0.450**	0.395**	0.431**	0.557**	0.561**	0.528**
Powerless/powerful	0.415**	0.400**	0.398**	0.418**	0.532**	0.514**	0.510**

Notes: **Significance at $p < 0.001$; *significance at $p < 0.05$. Italic type denote variables with high loadings on the same factor in exploratory factor analysis

(*continued*)

Table A3.

Item	Miserable/delightful	Relaxed/stimulated	Inactive/active	Submissive/dominant	Weak/strong	Powerless/powerful
Emotionally cold/ emotionally warm	0.661**	0.086**	0.312**	0.177**	0.469**	0.415**
Cool/ warm	0.605**	0.090**	0.300**	0.191**	0.450**	0.400**
Cold/hot	0.438**	0.234**	0.372**	0.252**	0.395**	0.398**
Not touching/ touching	0.562**	0.103**	0.314**	0.108**	0.431**	0.418**
Bad/good	0.803**	0.078**	0.337**	0.259**	0.557**	0.532**
Negative/positive	0.794**	0.074**	0.336**	0.238**	0.561**	0.514**
Unpleasant/pleasant	0.819**	0.050*	0.311**	0.239**	0.528**	0.510**
Miserable/delightful	*1*	0.137**	0.382**	0.248**	0.541**	0.513**
Relaxed/ stimulated	0.137**	*1*	0.530**	0.320**	0.248**	0.266**
Inactive/active	0.382**	*0.530***	*1*	0.431**	0.505**	0.508**
Submissive/dominant	0.248**	0.320**	0.431**	*1*	0.497**	0.552**
Weak/strong	0.541**	0.248**	0.505**	*0.497***	*1*	0.726**
Powerless/powerful	0.513**	0.266**	0.508**	*0.552***	*0.726***	*1*

Table A4. Pearson correlation matrix of all final scale items for the negative emotions groups (Study 2)

Item	Emotionally cold/ emotionally warm	Cool/warm	Cold/hot	Not touching/ touching	Bad/good	Negative/ positive	Unpleasant/ pleasant
Emotionally cold/ emotionally warm	*1*	0.692**	0.623**	0.597**	0.499**	0.510**	0.467**
Cool/ warm	*0.692***	*1*	0.694**	0.544**	0.434**	0.446**	0.426**
Cold/hot	*0.623***	*0.694***	*1*	0.470**	0.378**	0.376**	0.367**
Not touching/ touching	*0.597***	*0.544***	*0.470***	*1*	0.524**	0.528**	0.514**
Bad/good	0.499**	0.434**	0.378**	0.524**	*1*	0.801**	0.771**
Negative/positive	0.510**	0.446**	0.376**	0.528**	*0.801***	*1*	0.791**
Unpleasant/pleasant	0.467**	0.426**	0.367**	0.514**	*0.771***	*0.791***	*1*
Miserable/delightful	0.449**	0.402**	0.367**	0.478**	*0.727***	*0.732***	*0.762***
Relaxed/ stimulated	0.126**	0.171**	0.246**	0.063**	−0.008	0.007	−0.021
Inactive/active	0.289**	0.288**	0.354**	0.232**	0.250**	0.256**	0.236**
Submissive/dominant	0.195**	0.255**	0.273**	0.178**	0.279**	0.293**	0.286**
Weak/strong	0.299**	0.341**	0.353**	0.268**	0.411**	0.409**	0.402**
Powerless/powerful	0.256**	0.302**	0.317**	0.239**	0.377**	0.415**	0.404**

Notes: **Significance at $p < 0.001$. Italic type denotes areas denote variables with high loadings on the same factor in exploratory factor analysis

(*continued*)

Table A4.

Item	Miserable/delightful	Relaxed/stimulated	Inactive/active	Submissive/dominant	Weak/strong	Powerless/powerful
Emotionally cold/ emotionally warm	0.449**	0.126**	0.289**	0.195**	0.299**	0.246**
Cool/ warm	0.402**	0.171**	0.288**	0.255**	0.341**	0.302**
Cold/hot	0.367**	0.246**	0.354**	0.273**	0.353**	0.317**
Not touching/ touching	0.478**	0.063**	0.232**	0.178**	0.268**	0.239**
Bad/good	0.727**	−0.008	0.250**	0.279**	0.411**	0.377**
Negative/positive	0.732**	0.007	0.256**	0.293**	0.409**	0.415**
Unpleasant/pleasant	0.762**	−0.021	0.236**	0.286**	0.402**	0.404**
Miserable/delightful	*1*	0.025	0.292**	0.340**	0.443**	0.450**
Relaxed/ stimulated	0.025	*1*	0.489**	0.334**	0.272**	0.271**
Inactive/active	0.292**	*0.489***	*1*	0.522**	0.528**	0.529**
Submissive/dominant	0.340**	0.334**	0.522**	*1*	0.656**	0.675**
Weak/strong	0.443**	0.272**	0.528**	*0.656***	*1*	0.728**
Powerless/powerful	0.450**	0.271**	0.529**	*0.675***	*0.728***	*1*

Appendix 2

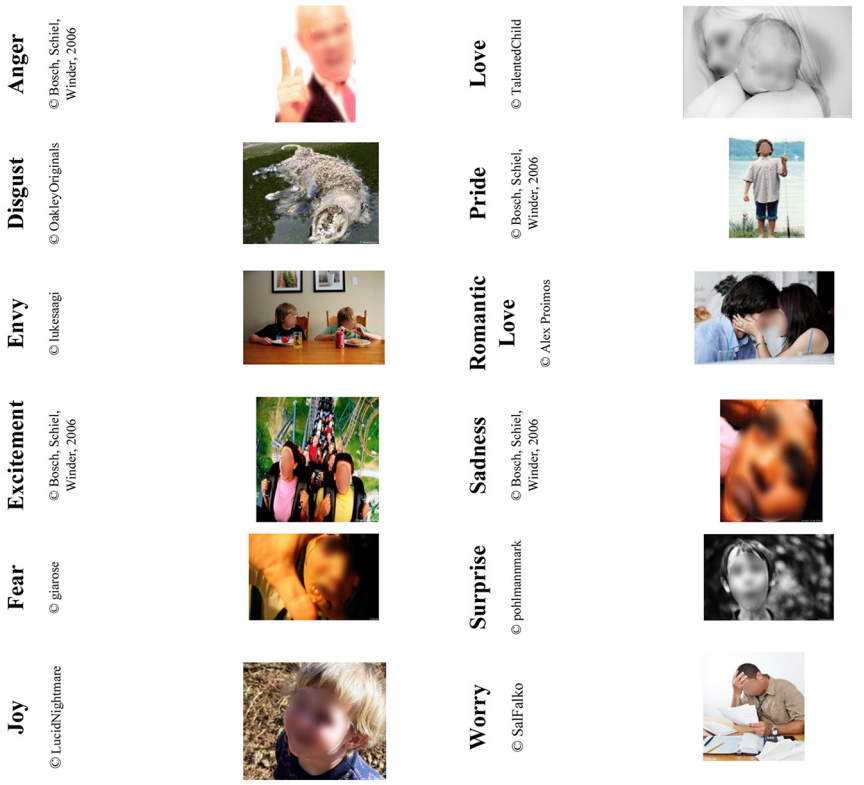

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Figure A1.
Visual stimuli used in Study 1b

Appendix 3. Full phrasing of the questions and scales in Studies 1a, 1b and 2

Full phrasing of the questions and scales used for Study 1a.

In the following, you will see a couple of emotion terms.
Please indicate to which degree these terms evoke specific associations. Proceed now to get to the emotion terms.

Please have a look at the following emotion term.

== Semantic stimulus (emotion term) ==

I would describe the emotion as:

	(-3)	(-2)	(-1)	(0)	(1)	(2)	(3)	
Not touching								Touching
Coldhearted								Warmhearted
Emotionally cold								Emotionally warm
Negative								Positive
Unpleasant								Pleasant
Miserable								Delightful
Bad								Good
Weak								Strong
Powerless								Powerful
Submissive								Dominant
Calm								Excited
Relaxed								Stimulated
Inactive								Active

Full phrasing of the questions and scales used for Study 1b.

In the following, you will see a couple of photos.
Please indicate to which degree these photos evoke specific associations. Further, we are interested in your attitude towards the respective picture. Proceed now to get to the photos.

Please have a look at the following photo.

== Visual stimulus (emotional picture) ==

I would describe the emotion I associate with the photo the most as:

	(-3)	(-2)	(-1)	(0)	(1)	(2)	(3)	
Not touching								Touching
Coldhearted								Warmhearted
Emotionally cold								Emotionally warm
Negative								Positive
Unpleasant								Pleasant
Miserable								Delightful
Bad								Good
Weak								Strong
Powerless								Powerful
Submissive								Dominant
Calm								Excited
Relaxed								Stimulated
Inactive								Active

Full phrasing of the questions and scales used for Study 2.

Please have a look at the following emotion terms and answer the corresponding questions.
We are interested in the extent to which the emotion terms evoke specific associations for you.

Please proceed now to get to the first emotion term.

== Semantic stimulus (emotion term) ==

I would describe the emotion as:

	(-3)	(-2)	(-1)	(0)	(1)	(2)	(3)	
Emotionally cold								Emotionally warm
Cool								Warm
Cold								Hot
Not touching								Touching
Bad								Good
Negative								Positive
Unpleasant								Pleasant
Miserable								Delightful
Relaxed								Stimulated
Inactive								Active
Submissive								Dominant
Weak								Strong
Powerless								Powerful

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