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On the cultural universality of getting “the chills”: Goosetingles and coldshivers as distinct responses to the awesome and the awful

By

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Abstract

On the cultural universality of getting "the chills": Goosetingles and coldshivers as distinct responses to the awesome and the awful

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"The chills" refers to a constellation of cold-defense sensations elicited by emotionally significant events. I examined the universality of chills sensations among 2,761 individuals across 26 countries distributed across 6 continents.

Across these varying cultures, analyses revealed two types of chills with distinct subjective and social correlates: goosebumps and tingling ("goosetingles") and coldness and shivers ("coldshivers"). Goosetingles accompanied positive emotions, most notably awe, were elicited by reward, and predicted social closeness. Coldshivers accompanied negative emotions, most notably fear and disgust, and was elicited by threat, and predicted social separation. Some elicitors (e.g., success, failure) had stronger effects in cultures where they are more novel. Others, particularly those critical to evolutionary fitness (sexual arousal, danger), had strong effects regardless of culture. Coldshivers predicted separation more strongly in colder climates. These findings document universal approach- and avoidance-specific bodily sensations that reveal the thermoregulatory roots of emotion and social bonds.

Dedication

To my father, John Maruskin

Acknowledgements

First, I want to thank my mother, Lynn Maruskin, and my sister, Katie Maruskin, for their love and support during this long academic journey of mine.

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Introduction

"**Bernstein:** And I pressed the button for this awful coffee in the machine. And I felt *a chill*. I remember it to this day. I turned around to Woodward and said, 'Oh my God, this president is going to be impeached.'

Woodward: I realized this was no flight of fancy. And said, 'You're right.'"

(NBC News transcript, 2005; italics added)

In a 2005 interview with Tom Brokaw, Carl Bernstein and Bob Woodward recalled a pivotal moment in the midst of the Watergate scandal when they realized that president Nixon would be impeached—a realization that occurred over coffee 40 years prior to the NBC interview. This account reveals a peculiar human phenomenon. During peak emotional experiences, whether poignant or profound, an individual's body sometimes reacts as if it were cold. This phenomenon is referred to as "the chills"—a set of bodily sensations, such as goosebumps and shivering—that sometimes accompanies strong emotion (Maruskin, Thrash, & Elliot, 2012).

Lay reports of "getting the chills" span several different kinds of experiences. Common examples include reports of feeling chills sensations when witnessing the birth of a child, or hearing news of the death of a loved one. People also speak of getting the chills in response to other, ostensibly more benign events, like when listening to a pleasant song, or being startled by someone approaching them unexpectedly from behind. The exchange between Bernstein and Woodward highlights three key features of the chills that support the uniqueness and importance of such experiences. First, one's own chills experiences *alert* oneself to poignant life events—in this case, the intuition of a forthcoming presidential impeachment. Second, the report of chills sensations *communicates* to and alerts others of the poignancy of the event that elicited these sensations—Woodward knew Bernstein's revelation was "no flight of fancy." Third, the events that elicit chills experiences are *remembered*—after 40 years, Bernstein and Woodward both recall this "aha!" moment vividly. These three features suggest that chills sensations, which seem to have roots in thermoregulatory processes for cold-defense, may have evolved to also serve social functions, important for binding social groups and alerting us to existentially relevant threat and reward. Further, if it is the case that chills experiences have their roots in evolutionarily old, thermoregulatory processes, it should follow that the chills is culturally universal due to these shared roots.

Present research

The purpose of the present research was to examine issues related to the cross-cultural universality of chills experiences. Specifically, I hypothesized that if chills experiences have in fact been partially repurposed from their original cold-defense functions, then it should follow that core features of chills experiences (e.g., factor structure, emotion correlates) are consistent across cultures. To test this claim, I examined thermo-emotional sensations associated with chills in 26 diverse cultures. The central hypothesis is that fundamental characteristics of chills experiences are culturally universal due to their evolutionary roots in basic thermoregulatory

processes.

Bodily processes and emotion specificity

Interest in the connection between the subjective experience of specific emotions and associated bodily processes is a classic question in emotion science that has recently re-emerged as a popular topic of inquiry. Darwin (1872) famously studied the bodily processes associated with specific emotional states through an evolutionary lens. William James (1884/1922) was one of the first psychologists to give this idea formal treatment. In doing so, James radically changed fundamental ideas within the field of research on emotion. In contrast to theorists at the time (e.g., Cannon, 1927), James posited that the subjective experience of emotion follows, rather than precedes, the physical responses in one's body—arguing that emotional experience is actually the perception (whether conscious or unconscious) of physical changes in one's body. Taking this idea one step further, James also posited that the subjective experience of every emotion involves a *distinct* set of physical responses (which he referred to as "bodily reverberations") that are associated with the experience of that emotion. These bodily reverberations included a wide array of responses that are a central focus of emotion research today—including patterns of respiration, heart rate, tears, the blush, gastric activity, and goosebumps. This work inspired modern peripheralist theories of emotion which have further explored the mind-body connection in the emotion literature—examining how specific bodily responses map onto felt experiences of specific emotions (e.g., Damasio, 1996; Friedman, 2010; Levenson, Friesen, & Ekman, 1990; Price & Harmon-Jones, 2015).

Research on the bodily processes and sensations associated with specific emotions has spanned several different kinds of emotional experiences—from negative emotions, like fear and disgust, to positive emotions, like love and enthusiasm, to more complex emotions, like awe. Other research has taken a different approach. Rather than mapping specific bodily processes onto different kinds of emotional experiences (e.g., positive, negative, complex), this research starts by looking at the body holistically and considering a broad range of emotional experiences. I describe a sampling of these lines of research below.

One manifestation of James's theorizing comes from Paul Ekman and colleague's classic work on facial expressions and emotion (e.g., Ekman, Friesen, & Ancoli, 1980; Ekman, Sorenson, & Friesen, 1969). Ekman and colleagues focused on six basic emotions—happiness, sadness, fear, anger, disgust, and surprise—and sought to understand the specific facial muscle movements that accompany subjectively experienced emotions. They found that participants' subjective experience of different emotions mapped onto replicable patterns of facial muscle activity. These results have been further examined and replicated in myriad cultures around the world (e.g., Ekman, 1993)—suggesting a *universality* in the correspondence of specific bodily responses with specific emotions. More recently, Durán, Reisenzein, & Fernández-Dols (2017) found further support in a meta-analysis of the coherence between emotion and facial expression. Taken together, this work is consistent with the Jamesian approach in that specific "bodily reverberations" (in this case, contraction of facial muscles) are differentiated in the subjective experience of distinct emotional responses. This work also led to the development of the Facial Actions Coding System (FACS; Ekman & Friesen, 1978), providing objectivity to the measurement of the expression of specific emotions in research studies.

In other work, Levenson and colleagues focused on the physiological profiles of specific emotional states using a directed facial action task and examined whether the mere action of

making the facial expression associated with a particular emotion was enough to elicit the physiological activity associated with that emotion (Levenson, Friesen, & Ekman, 1990). Participants were given specific muscle-to-muscle instructions to follow in order to configure their faces into each of Ekman's six basic emotions while measures of autonomic activity were collected—heart rate, finger temperature, skin conductance, and muscle activity. Results provided initial evidence for physiological specificity for the different emotion, and further, evidence for the Jamesian idea that emotion-related changes in one's body may precede the subjective experience of emotion, and at the very least, are separable in the lab. Much of this original research tended to focus on negative emotion, but more recent research has examined the nuances of differentiated autonomic activity associated with myriad emotional states, including with positive emotions like awe and love (e.g., Shiota, Neufield, Yeung, Moser, & Perea, 2011).

More recent work on bodily processes and emotion specificity has expanded the set of emotions and examined the universality of facial-bodily expressions of 18 emotions across nine cultures (Cordaro, Sun, Kamble, Hodder, Monroy, Cowen, Bai, & Keltner, 2019). Specifically, Cordaro and colleagues created empirically derived photos of facial-bodily expressions for Ekman's six basic emotions, and added the less-studied states of amusement, contentment, desire, embarrassment, interest, pain, pride, shame, sympathy, boredom, confusion, and coyness. College students sampled from China, Germany, India, Japan, Pakistan, Poland, South Korea, Turkey, and the U.S. were asked to identify the facial-bodily expression photo that was indicated in causal-antecedent stories designed to depict one of the 18 target emotions. Across all cultures, the 18 facial-bodily expressions were recognized well above chance, providing evidence for the universality of specific expressive behavior mapping onto specific emotional states.

A final approach to assessing bodily processes and emotion-specificity is to consider where on the body specific emotions are experienced. Nummenmaa, Glerean, Hari, & Hietanen (2014) employed a particularly novel approach to the study of the bodily sensations and emotion specificity by using a topographical self-report method. They showed participants two silhouettes of bodies alongside 13 emotional words—anger, anxiety, contempt, depression, disgust, envy, fear, happiness, love, pride, sadness, shame, and surprise—and asked them to color the body in the area they felt activity increasing or decreasing for each emotion. Across five experiments in West European and East Asian samples, different emotions were associated with reported activation in different, statistically separable areas of the body. This work provides a unique and important piece of evidence into the universality of bodily sensations and emotion specificity. Notably, the consideration of the full body in the experience of specific emotions is particularly relevant to the current investigation on the universality of the chills construct.

The chills as a psychological construct: Methods and findings

Initial efforts to define and identify core characteristics of chills experiences yielded an array of diverse and sometimes contradictory conclusions. Early in the field, fundamental issues, such as defining the chills construct were overlooked and the majority of studies of the chills focused on chills elicited in response to music specifically, rather than in response to generalized stimuli (e.g., Panksepp, 1995; Sloboda, 1991; for an exception, see Goldstein, 1980). In addition, measurement approaches also differ across studies—ranging from subjective self-report to objective brain activity. I describe these divergent methods below, as well as how these and other factors have led to divergent conclusions about fundamental features of chills experiences.

Methods for measuring chills

Surprisingly, issues of measurement and methodological concerns more generally are often treated as an afterthought in the research process, in particular in studying emotion-related bodily responses. Proper identification of constructs, including the measured components that load onto latent constructs, is fundamental to theoretically driven work in psychology and across sciences (e.g., Bollen, 1989). Lack of methodological rigor and inconsistent measurement has been a thorn in the side of the chills literature and has led to inconsistent findings and disagreement across studies. For example, the specific sensations used to define "the chills" differs across studies (see, Maruskin et al., 2012). Issues as seemingly obvious as empirically identifying the physical sensations that comprise the chills construct have snowballed into contradictory conclusions about the emotion profile of chills experiences and the kinds of situations most likely to elicit chills.

Regarding methods of measurement per se, some studies have focused on subjective self-reports with items, such as "Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement" (McCrae, 2007). In other studies, the chills are measured with more objective correlates, such as physiological measures (e.g., skin conductance, Grewe, Nagel, Kopiez, & Altenmüller, 2007); skin temperature; (Craig, 2005) and brain imaging (e.g., PET, Blood & Zatorre, 2001). As a result, the study of the chills, has occurred in disparate literatures resulting in a segmented, rather than incremental, approach to chills research overall, likely exacerbated inconsistencies. As a result, "the chills" has been defined by a variety of physical sensations, elicitors, and emotions across studies. I discuss these inconsistencies in more detail below.

Physical sensations that define chills

Recent empirical work has examined different physical sensations as a way of understanding emotion specific physiology and experience (Nummenmaa et al., 2014). Some sensations—such as the blush (e.g., Leary, Britt, Cutlip, & Templeton,1992) and incipient weeping (e.g., Lutz, 1999)—map onto fairly specific physiological responses. By contrast, when people report experiencing the chills, they potentially refer to a multiplicity of physiological responses. As a result, the physical sensations used to define "the chills" in the early literature vary, with some generated by researcher's lay conceptualizations of chills and the vast minority of others derived empirically. For example, researcher-generated definitions include: "a pleasant physical sensation often experienced as a 'shiver' or a 'tingle' running from the nape of the neck down the spine" (Sloboda, 1991, p. 110), "a subtle nervous tremor caused by intense emotion" (Grewe, et al., 2007, p. 297), and a "feeling of goose bumps, tingling, and shivers" (Nusbaum & Silvia, 2011, p. 297). Empirically derived definitions based on participants' descriptions of their own chills experience include "a chill, shudder, tingling, or tickling [that] may be accompanied by a feeling of 'hair standing on end' or 'goose bumps' on the arms" when referring to a variety of potential elicitors of chills (Goldstein, 1980, p. 127) and identified "a wide distribution of body areas where chills were primarily felt, with the most common report being 'all over the body' followed successively by the head, face, neck, and back" when referring to chills in response to music" (Panksepp, 1995, p. 173). Critically, these definitions, although intuitive, collapse different sensations with likely distinct physiological underpinnings (e.g., the shudder

versus goosebumps)

Despite these concerns, it is of note that across studies, physical sensations that comprise the chills have been identified as some combination of the following: goosebumps/piloerection (e.g., Darwin, 1872; Grewe et al., 2007; Huron, 2006; Nusbaum & Silvia, 2011; Panksepp, 1995), shivers or a shudder (e.g., Erikson, 1958; Nagel, Kopiez, Grewe, & Altenmüller, 2008; Panksepp & Bernasky, 2002; Sloboda, 1991), feeling cold or a chill (e.g., Goldstein, 1980; Huron, 2006), and tingling or tickling sensations (e.g., Goldstein, 1980; Panksepp, 1995, 1998; Sloboda, 1991). In sum, definitions varied in the particular sensations identified as well as the extent to which the objective vs. subjective components of bodily responses are emphasized—but importantly, and as will be addressed in detail in a later section, these candidate chills sensations each serve a particular thermoregulatory function.

More specifically, these candidate sensations all represent particular cold-defense mechanisms. Piloerection (goosebumps) enhances insulation by trapping heat on the surface of the skin. Shivering generates heat through movement. Detectable feelings of physical coldness motivate heat-seeking behavior, such as moving to a warmer location or putting on a sweater. The thermoregulatory function of tingling is the most unclear but may be the feeling of one's hair standing on end or the sensation associated with vasoconstriction, the constriction of blood vessels blood is drawn to one's core.

Elicitors

One conceptual approach for understanding the meaning of physical sensations is to identify core appraisal themes that conceptually unite the elicitors of the chills sensations. For example, in their exhaustive review of the immediate causes of the blush, Leary and colleagues found that elicitors that involve negative self-evaluation elicit the blush (Leary et al., 1992). Select studies have sought to understand the core themes to the elicitors of the chills, with some ambiguity in the results. In an attempt to identify the scope of chills elicitors, Goldstein (1980) asked participants to nominate stimuli that gave them chills and then sorted these into categories and ranked them based on frequency. The category of elicitors that was most frequently identified was musical passages. Other categories included movie scenes, sexual activity, moments of inspiration, and parades. Although this research provides a relatively comprehensive sense of the range of potential elicitors of chills, it provides little grounding in psychological theory.

As noted, the majority of early research on elicitors of chills focused on features of music that tend to elicit chills. Some studies asked participants to nominate a particular piece of music that reliably gave them chills (e.g., Panksepp, 1995; Sloboda, 1991) while others had participants listen to a piece of music that the researchers had identified as adept for eliciting chills (e.g., Blood & Zatorre, 2001). Regarding the specific moments in musical piece that marked moments of participant chills, Panksepp & Bernasky (2002) speculated that a "high-pitched, sustained crescendo, a sustained note of grief sung by a soprano or played on a violin (capable of piercing the 'soul' so to speak)" may be ideal for evoking self-reported chills. The researchers provided a preliminary evolutionary account of this phenomenon, speculating that at these moments, the music resembled the separation calls of an infant and that may elicit chills in the mother, calling her attention to the infant, and motivating her to reunite with and tend to the infant (Panksepp, 1998). Other researchers agreed that specific musical features, such as crescendos, unexpected harmonies, and surprising rhythmic changes, are particularly adept for eliciting chills (Guhn,

Hamm, & Zenner, 2007; Panksepp, 1995; Sloboda, 1991). Huron (2006) later suggested that unexpected stimuli are particularly adept at eliciting chills—an idea that is consistent with the nominated musical features. Finally, across studies, elicitors have differed in whether they tended to be positive or negative in nature. For example, Goldstein (1980) focused on pleasant elicitors, whereas Panksepp & Bernasky (1991) emphasized sad/melancholy portions of musical pieces.

In sum, in early investigations of chills, a variety of candidate elicitors were suggested—whether examining general elicitors or specific features of music. Two important features of this early work are noteworthy: the lack of clear distinctions between the different sensations that make up the chills; and little theoretical grounding and consistent empirical support.

Emotion correlates

A second approach to mapping the meaning of an emotion-related sensation is to study the subjective emotion correlates of the sensation. This has been done in the blush, for example, where studies find this sensation maps on to experiences of embarrassment more so than other emotions, such as shame or fear (e.g., Keltner & Buswell, 1997; Sheam, Bergman, Hill, Abel, & Hinds, 1992). Select studies are finding that the emotion correlates of chills also vary. Although theories agree that the chills involve heightened affect, chills have been linked to a variety of emotional states; as a result, contradictory claims have been made about whether the chills are associated with positive emotions, negative emotions, or more complex, self-transcendent emotional states, such as awe, ecstasy, and joy.

Regarding positive emotions, several researchers have highlighted the pleasantness of chills experiences. Goldstein (1980) portrayed chills as euphoric, going as far as comparing the response to an orgasm. Blood and Zatorre (2001) found that chills was related to blood flow in brain areas associated with pleasure and reward, including ventral striatum, midbrain, amygdala, orbito- frontal cortex, and ventral medial prefrontal cortex. Huron (2006) conceptualized chills as a pleasurable experience that people often seek out from music, which is consistent with other empirical accounts of the pleasantness of chills in response to music (e.g., Grewe, Nagel, Kpiez, & Al, 2005; Grewe et al., 2007). Campos and colleagues found that elevated chills covaried with reports of awe, gratitude, love, and compassion, with awe being the emotion most likely to be associated with the chills (Campos, Shiota, Keltner, Gonzaga, & Goetz (2013).

In contrast, Panksepp (1995) argued that sadness and melancholy are the emotions most commonly associated with chills, and reported, anecdotally, that sad songs are more effective than happy songs at eliciting chills. Grewe, Katzur, Kopiez, and Altenmüller (2011) posited that the positivity or negativity of chills experiences depends on the type of elicitor—namely that chills caused by music was associated with pleasant affect, whereas chills caused by pictures or non-musical sounds was unpleasant. Finally, more recent research has linked chills to complex, self-transcendent emotional states (Campos et al., 2013). Laski (1961) reported that chills sensations commonly accompany experiences of ecstasy. Chills have also been linked to wonder (Baltes, Avram, Micela, & Miu, 2011), admiration (Algoe & Haidt, 2009), awe (Keltner, 2009; Konecni, 2008; Pearsall, 2007), and surprise (Huron, 2006; McCrae, 2007).

These conflicting conclusions suggest two theoretical possibilities about the emotional composition of the chills: (1) the chills is an indicator of general, undifferentiated arousal, or (2) the chills is a differentiated construct composed of two underlying components—one positively valenced and the other negatively valenced. In the following, I present a unifying theory of

chills.

An initial taxonomy and theoretical approach to chills

The brief review above reveals basic ambiguities and contradictory patterns of results. The chills is not consistently defined in terms of the specific sensations that the concept refers to, from one study to the next. And there are contradictory results in the studies: sometimes the chills covaries with negative emotional experiences, sometimes positive experiences. This could be characteristics of the chills; it may simply be a complex sensation that accompanies a variety of emotions when experienced at intense levels. Or, more precise theorizing and measurement might yield clearer statements about the meaning of this sensation, or family of sensations.

Discrepancies regarding core sensations, elicitors, and emotion correlates in the early chills literature are resolved when basic construct validation issues are addressed. These initial attempts to study the chills tended to overlook fundamental characteristics of the chills construct, such as the physical sensations that define the chills and the factor structure of these sensations. In the following I describe more recent research that has provided and empirically derived definition of chills, and how proper identification of the factor structure of chills sensations explains apparent contradictions in early theorizing and research.

Physical sensations and factor structure

As noted above, the majority of research on the chills has relied on researcher-generated definitions of the physical sensations that comprise the chills construct. In contrast, Maruskin et al. (2012) treated the issue of what physical sensations define the chills as an empirical question and addressed it first in a series of theoretically-driven studies on fundamental characteristics of chills experiences. A central aim of this approach was to avoid the bias that can be inadvertently introduced when researchers' assumptions creep into the research process without empirical support.

In this study, a first sample of participants (35 introductory psychology students) described what it means to get "the chills" Research assistants then extracted all references to physical sensations from these descriptions. A second sample of participants (22 undergraduate and graduate students) categorized the sensations based on similarity. A hierarchical cluster analysis of participant-generated sensations associated with "the chills" yielded four core chills sensations—goosebumps, tingling, coldness, and shivering. These four core sensations were subsumed by two higher-order clusters—"goosetingles" (goosebumps and tingling) and "coldshivers" (coldness and shivering). The multi-level structure of chills based on the cluster analysis of similarity ratings of chills sensations was replicated with a factor analysis of the co-variance of chills sensations in a narrative recall study of experiences of chills. That is, not only were the two pairs of sensations that make up goosetingles and coldshivers rated as more similar to each other than any other combination of the four sensations, but when a person reported having experienced one of the four sensations, they tended to report experiencing the sensation corresponding to the hypothesized goosetingles-coldshivers structure pair.

For the first time, this research provided empirical evidence for (1) the bodily sensations that define the chills construct and (2) the factor structure of these sensations. The following sections will focus on how the goosetingles-coldshivers structure of the chills construct reconciles apparent contradictions in elicitors and emotion correlates of chills.

Elicitors

Regarding elicitors of chills, the goosetingles-coldshivers distinction provides a framework for apparently inconsistent findings: namely, the two sensations identified in my research—goosetingles and coldshivers—are elicited by different kinds of stimuli (Maruskin et al., 2012). Derived from coding of participants' narratives about past experiences of overall chills, data indicated that ratings of goosetingles and coldshivers are elicited by approach- and avoidance-related stimuli, respectively. Specifically, aesthetic beauty and sexual attraction/arousal elicited goosetingles rather than coldshivers. By contrast, the threat of losing social ties and threats to one's physical well-being elicited coldshivers rather than goosetingles.

These findings not only reconcile the contradictory claims about the positive (e.g., Grewe et al. 2005) and negative (e.g., Panksepp, 1995) nature of elicitors of chills, but also extend research from musical features to general stimuli.

Emotion correlates

Ambiguity regarding the emotion correlates of chills is also clarified by the goosetingles-coldshivers factor structure. In a study designed to replicate the factor structure of the chills construct and document emotion correlates of each type of chills, Maruskin et al. (2012) asked participants to recall a time when they experienced the chills in response to an emotionally evocative event. Participants then rated the extent to which they experienced each of the four chills sensations and the intensity with which they experienced eight discrete emotions—interest, enjoyment, surprise, awe, sadness, anger, disgust, and fear. A principal components analysis of the chills sensations replicated the goosetingles-coldshivers structure. Regarding emotion correlates, goosetingles was associated with positively valenced emotions (e.g., awe, positive surprise) and coldshivers was associated with negatively valenced emotions (e.g., fear, disgust).

This work reconciles extant competing hypotheses regarding the emotional tone of chills experiences by taking into account the multi-factor structure of the chills construct. It is not the case that overall chills is either associated with positive *and* negative emotions—the goosetingles sub-factor of overall chills tends to be associated with positively valenced emotions, such as …, whereas the coldshivers sub-factor tends to be associated with negatively valenced emotions, such as disgust and fear. In addition, these findings indicate that chills experiences are not mere indicators of generalized arousal, but rather differentiated arousal when the construct is properly defined.

Social consequences

To date, theorizing about the functional significance of getting the chills has focused on interpersonal outcomes. As noted in above, Panksepp (1995) proposed that the chills were associated with separation distress between and mother an infant, and that the chills functioned as an aversive, thermally-based motivation for social reunion. Whereas Panksepp posited that chills accompanies instances of separation, Keltner (2009) emphasized the feelings of closeness and connectedness that can accompany the chills. Again, this discrepancy of social consequences of chills seems to hinge on the need for a proper identification of the structure of the chills construct.

Maruskin and colleagues (2012) addressed this issue by examining the social consequences of goosetingles vs. coldshivers with an experimental design. Participants were randomly assigned to view one of two video clips. Participants in the goosetingles condition viewed a video clip depicting self-actualization—Susan Boyle singing "I Dreamed a Dream" from Les Miserables on *Britain's Got Talent.* Participants in the coldshivers condition viewed a video clip depicting self-annihilation—two performers creating the illusion of mutilating their arms with knives while stroking imagined violins. Results indicated that participants in the goosetingles condition reported greater feelings of social closeness and participants in the coldshivers condition reported greater feelings of social distance.

In sum, the diversity of conclusions in the nascent literature is attributable to a lack of attention to fundamental issues sthat stem from misidentification of the factor structure of the chills construct. The chills construct is not a unitary but rather is comprised of two distinct subfactors—goosetingles" (goosebumps and tingling) and coldshivers (coldness and shivering). Goosetingles and coldshivers are defined by different physical sensations, predicted by different kinds of elicitors (approach- or avoidance-related, respectively), associated with different emotions (e.g., awe vs. fear, respectively), and lead to different social outcomes (closeness vs. distance, respectively).

Universality of chills

Conceptualization and measurement of universality

The idea that certain psychological phenomena generalize across cultures is fundamental to the field of psychology and establishing universality is the focus of much empirical research. Spanning sub-disciplines and topics, there are several research strategies for establishing cross-cultural universality. Norenzayan & Heine (2005) described a sampling of strategic approaches that differ primarily on the number of cultures that are studied in each approach. On one end of the spectrum, is the "two cultures" approach, which is the simplest approach and aims to derive support for universality by comparing two cultures that vary as greatly as possible on theoretically relevant dimensions, such as language, social norms, geography, socio-economic status, and levels of education. The extent to which there is similarity in psychological processes in cultures that differ so greatly, and in such meaningful ways, is seen as evidence for universality. However, when there are differences in psychological phenomena found across the two cultures, this approach is limited in that it is difficult to identity the particular cultural difference that is driving the effect (simply because there are so many). On the other end of the spectrum, Norenzayan & Heine (2005) describe the "cross-cultural" approach, in which a wide variety of cultures, are assessed with the aim of establishing the universality of a psychological phenomenon using the same measures. This approach is the most rigorous in the sense that it involves an effort toward representative sampling from the world's population of cultures, with their near infinite differences. This strategy has resulted in highly influential work, on topics such as the universality of emotion categorization (Russell, 1991), predictors of subjective well-being (Diener, Diener, & Diener, 1995), and evolutionary roots of interpersonal relationships (e.g., Buss, 1989). The present research adopts this cross-cultural approach to studying the universality of the chills.

Potential thermoregulatory roots

Theorizing about cross-cultural universality often looks to common evolutionary roots as a reason for consistency. Here I reason that each of the four chills sensations serves a cold-defense purpose. More specifically, piloerection traps heat on the surface of the skin, shivering creates heat through movement, the subjective feeling of physical coldness motivates directed behavior to seek warmth, and tingling (the most nebulous of the sensations in terms of specific thermoregulatory association) may be the feeling of vasoconstriction—or, one's veins constricting peripherally to increase blood flow (and bring warmth) to one's centrally located vital organs. These evolutionary roots in thermoregulatory processes provide conceptual support for the connection between emotional chills and thermoregulation—but, why might orienting signals associated with the experience of strong emotion be associated by cold defense mechanisms? I propose that cold defense mechanisms tend to have a social utility that generalizes beyond their roles in cold defense.

Darwin first provided a precedent for claims of this nature in arguing that piloerection was re-purposed to make mammals with fur appear larger when threatened (Darwin, 1872). Subjective sensations of coldness have likewise been theorized to be recruited for purposes beyond its original function. In the social thermoregulation literature, sensations of coldness in an objectively cold environment are theorized to motivate social proximity, thus maintaining body temperature more efficiently than through internal physiological means (IJzerman et al., 2015)—a fascinating idea that we in a sense "outsource" thermoregulatory tasks to others in times of stress, so that the energy needed to keep one's body warm can be allocated to managing threat. That is, getting a cold chill in response to a nonthermal threat, such as separation or loss (Panksepp, 1995), may trigger social thermoregulatory behaviors, thus conserving energy that may be deployed during the subsequent action phase of the threat-avoidance process. A testable implication is that the social consequences of coldshivers should be greater in colder environments, where social thermoregulation is more prevalent (IJzerman et al., 2015). Thus, I hypothesized that the effect of coldshivers on feelings of separation would be stronger in colder climates.

McCrae (2007) provided the preliminary evidence of the cross-cultural universality of chills. McCrae analyzed personality questionnaire data in 51 counties and looked at how one item—"Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement" loaded on the trait Openness to Experience across cultures. Based on a strong cross-language factor loading of this item, he argued that aesthetic chills is the best universal marker of Openness to Experience. However, studies that have distinguished goosetingles and coldshivers have been conducted only with English-speaking samples from the U.S. Rooted in the belief that chills sensations are grounded in the neurophysiology of cold defense, rather than culturally constructed, I aimed to replicate, and generalize across diverse countries worldwide, past evidence of the distinctiveness of these thermo-emotional sensations. The alternative—that chills are culturally constructed—would predict cultural variation in the fundamental characteristics of chills experiences. Specifically, I aimed to generalize the findings discussed above concerning factor structure and distinct patterns of relations to emotion, elicitors, and interpersonal closeness. Such cross-cultural evidence of double dissociations may shed light on the interoceptive and homeostatic foundations of emotion (Craig, 2000; Damasio, 2003; IJzerman et al., 2015), as well as autonomic specificity underlying discrete classes of emotions (Levenson, 1992).

Central Aims and Hypotheses

The central aim of this research is to examine the universality of chills experiences. The general hypothesis is that core features of chills experiences are culturally universal due to their foundation in basic thermoregulatory processes. Specifically guided by my past research and the conceptualization developed thus far, I hypothesize that (1) thermo-emotional chills occur with similar frequencies in diverse cultures around the world; (2) the goosetingles-coldshivers factor structure of chills holds across cultures; (3) the emotion correlates of goosetingles and cold shivers are consistent across cultures; (4) within cultures, the elicitors of goosetingles and coldshivers are characterized by reward and threat (respectively) across cultures; (5) the within-level effects of particular elicitors on goosetingles vs. coldshivers in a particular will be moderated by the country's mean level of that elicitor; and (6) goosetingles and coldshivers are associated with social closeness and distance (respectively) across cultures.

Method

Participants

Participants were recruited from 26 countries: Argentina, Australia, Austria, Brazil, Canada, Chile, China, France, Germany, India, Indonesia, Ireland, Japan, Mexico, Netherlands, Norway, Russia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States. These countries span all continents except Antarctica and are diverse with respect to language, religion, economic structure, culture, and personality (Allik et al., 2017).

Data were collected by Qualtrics as part of their Qualtrics Panel online data collection service. Participants received monetary payment or other compensation depending on their contractual arrangement with Qualtrics. Participants were eligible to participate if they (a) currently lived in one of the 26 targeted countries, (b) had been born in that country, (c) had never lived outside the country for more than 2 years, and (d) were at least 18 years old. Quotas were imposed to balance gender, age, and the number of participants per country.

A sample of 3,385 participants provided at least partial data. Data from 203 participants who provided incomplete data were excluded from the final data set. Data from an additional 421 participants were excluded for one or more of the following reasons: (a) all four chills items were given a score of 1 (indicating absence of a relevant chills experience; N = 165), (b) all emotion items were given the same rating (likely indicating invalid responses; N = 109), (c) the survey was completed excessively quickly, as suggested by a histogram of durations (N = 56), or (d) the participant's narrative about the chills was flagged by coders as problematic (N = 330). A narrative was flagged if (a) the participant stated that he or she could not recall an instance of the chills (N = 182), (b) the chills experience was ineligible for inclusion because it was caused by illness or a cold environment rather than an emotionally evocative situation (N = 106), (c) the narrative consisted of inappropriate (e.g., nonsense) text (N = 36), or (d) the participant expressed difficulty with the language in which the materials were presented (N = 6). The two coders generated validity codes separately and resolved discrepancies through discussion. The final sample consisted of 2,761 participants. Information about the characteristics of the sample from each country is provided in Table 1.

Procedure

Participants completed this study and an unrelated study in one of two orders that was counterbalanced and determined randomly for each participant. Participants first recalled a time when they experienced chills and then completed a series of questionnaires about the experience.

Narrative recall task. Participants were asked to write a narrative account about an occasion when they felt at least one of four chills sensations in response to an emotionally evocative situation. The purpose of this task was two-fold: (1) it provided narrative data for coding the types of situations that elicit chills across cultures, and (2) it provided a functional purpose, in that it re-oriented participant to the experience, so that it would be fresh in their minds when filling out the subsequent questionnaires. After the narrative recall task, participants completed questionnaire measures of chills sensations, emotions, elicitors, and interpersonal closeness during the recalled experience. The narrative recall task was introduced with the following prompt:

> *Take a moment to recall a time when you felt one or more of the following sensations—goosebumps, tingling, feeling cold, or shivering—in response to an emotionally evocative experience (not as a result of nonemotional causes, such as cold air or illness). Please relive the experience and describe it in detail. In 5-7 sentences, describe (1) the situation, (2) how you felt, and (3) what it made you want to do (if anything) in the space below. If English isn't your native language, please feel free to respond in your native language.*

Participants then completed a set of questionnaires regarding their state during the recalled experience of the chills. These measures are presented below.

Self-report Measures

Chills sensations. Following Maruskin et al. (2012), chills sensations were assessed using the following items: goosebumps, "Had goosebumps or a hair on end feeling"; tingling, "Had a tingling or ticklish feeling"; coldness, "Felt cold or felt a chill"; shivers, "Felt a shiver or shudder." Items were rated from 1 (*not at all*) to 7 (*very strongly*).

Elicitors. Single items were used to assess each of ten elicitor categories were derived from two research assistants' independent coding of chills narratives in a prior study (Maruskin et al., 2012). Original positive elicitor categories were assessed with the following single items: the category "Thrilling experience or adventure" was assessed with the item "thrill"; "Sexual attraction or arousal" was assessed with the item "sexual arousal"; "An inspiring person or thing" was assessed with the item "inspiration"; "Something beautiful or aesthetically pleasing" was assessed with the item "beauty"; "Feeling close or connected to another person or group of people" was assessed with the item "closeness"; and finally, "A relaxing or calm situation" was assessed with the item "relaxation"; "An achievement (your own or someone else's)" was assessed with the item "success." Original negative elicitor categories were assessed with the following single items: "Feeling distant or separated from another person or group of people" was assessed with the item "separation"; "A failure (your own or someone else's)" was assessed with the item "failure"; and "Physical danger or risk of physical harm" was assessed with the item "failure." Items were rated from 1 (*not at all*) to 7 (*extremely*). Composite positive and

negative elicitor indexes were computed by averaging the respective items.

Emotions. Each of 20 emotional states was assessed with single items that consisted of both a verbal label ("Anger," "Anxiety," "Awe," "Confusion," "Contentment," "Curiosity," "Desire," "Disgust," "Enthusiasm," "Fear," "Gratitude," "Grief," "Happiness," "Joy," "Love," "Pride," "Sadness," "Shame," "Surprise," "Sympathy") and a visual depiction in the form of an emoji-like drawing (Bai, Cowen, Cordaro, McNeil, Simon-Thomas, Piff, Wilson, Jones, & Keltner, 2019). These drawings, created by a professional illustrator, tend to be recognizable to U.S. and Chinese participants even without verbal labels (Bai et al., 2019). Inclusion of both verbal and visual representations in the present study was intended to minimize problems of interpretation across cultures and languages, and the ambiguities of single emotion terms (Cordaro et al., 2019). Participants indicated the degree to which they had experienced each emotional state using a scale from 1 (*not at all*) to 7 (*extremely*). An index of positive emotion was computed as the mean of responses to the awe, contentment, curiosity, desire, enthusiasm, gratitude, happiness, joy, love and pride items. An index of negative emotion was computed as the mean of responses to the anger, anxiety, confusion, disgust, fear, grief, sadness, and shame items. The surprise and sympathy items were excluded from these indexes given that these states are not predominantly positive or negative in valence (cite?).

Closeness to community. Closeness to one's community was assessed using the Inclusion of Other in the Self Scale (Aron, Aron, & Smollan, 1992). Participants were shown a set of 7 pairs of circles labeled "Self" and "Others." The pairs of circles were presented with increasing degrees of overlap. Participants were asked to select the pair that best describes their relationship with their community during the recalled experience. Responses were coded from 1 (*no overlap*) to 7 (*nearly complete overlap*).

Country mean temperature. Country mean temperature was computed from the Climatic Research Unit (CRU) Country (CY) dataset, version 4.01. This data set was based on the CRU TS3.10 monthly gridded data set (Harris, Jones, Osborn, & Lister, 2014) but has been updated to include data through 2016 and reports data based on national borders rather than longitude and latitude. For each country in our study, the average reported annual mean temperature variable (TMP) was computed across the years 2007-2016. The data collection for the present study occurred in 2016, and therefore the 2007-2016 range spans the decade in which most of the recalled chills experiences likely occurred.

Results

Analytic strategy

Statistical models were tested using Mplus 8.0 (Muthén & Muthén, 2017). Multilevel modeling and multilevel structural equation modeling (MSEM) were used to account for the non-independence resulting from the nesting of individuals within countries. The estimator was maximum likelihood with robust standard errors (MLR), which yields standard errors and chi-square values that are robust to violations of normality. Study order and gender were controlled (with grand mean centering) in all analyses except for preliminary analyses of descriptives and factor structure. These and other control variables discussed below were modeled with fixed

effects. Reported coefficients are unstandardized, with the exception of correlation coefficients and factor loadings. Bracketed values indicate 95% confidence intervals.

Descriptive statistics

In order to test my first hypothesis and determine whether chills sensations occur with similar frequency across cultures, intraclass correlations were computed for goosetingles and coldshivers across countries. Table 2 presents descriptive statistics generated in a series of unconditional MSEM models. Grand means were as follows: goosebumps, M = 4.87; tingling, M = 3.69; coldness, M = 3.94; shivers, M = 4.58. The decomposition of goosetingles and coldshivers variables into latent within-country and between-country components revealed substantial within-country variability and modest between-country variability. Intraclass correlations ranged from .033 to .058, indicating that 3.3% to 5.8% of the variance in a given sensation existed at the between-country level. Thus, for each chills sensation, differences in country means were modest relative to the variability within countries. The similarity of means across 26 countries provides preliminary evidence that experiencing chills sensations during moments of emotion may be a universal phenomenon. These findings establish the occurrence of two types of chills sensations across a diverse set of languages and cultures.

Factor structure of the chills

In order to test my second hypothesis and determine the factor structure of chills across cultures, a multilevel confirmatory factor analysis was conducted to test the hypothesized goosetingles-coldshivers factor structure. Consistent with my findings in U.S. samples (Maruskin et al., 2012) I expected a two-factor structure such that observed indicators of goosebumps, tingling, coldness, and shivers were partitioned into latent between-country and within-country components using MSEM. At the within-country level, tingling and goosebumps were specified to load on a goosetingles factor, and coldness and shivers were specified to load on a coldshivers factor. At the between-country level, the four sensations were allowed to correlate freely due to difficulty in successfully fitting a factor structure at the between-country level, where there was little variance. The two-factor model had excellent fit, χ^2 (1) = .63, p = .43, TLI = 1.01, CFI = 1.00, RMSEA = .00, SRMR = .01. Standardized factor loadings were as follows: goosebumps, .60 [.54, .66]; tingling, .42 [.31, .52]; coldness, .63 [.56, .70]; shivering, .74 [.66, .83]. The goosetingles and coldshivers factors were strongly correlated, r = .69 [.52, .86]. Nevertheless, a one-factor model, in which all four sensations loaded on a general chills factor, had substantially worse fit, χ^2 (2) = 26.72, p < .001, TLI = .70, CFI = .95, RMSEA = .07, SRMR = .04. On the basis of these findings, goosetingles and coldshivers composite variables, rather than an overall chills variable, were examined in subsequent analyses.

Emotion correlates

Regarding my third hypothesis on emotion correlates of goosetingles and coldshivers, I hypothesized that goosetingles would be positively correlated with positive emotions and that coldshivers would be positively correlated with negative emotions—this is consistent with my findings in the U.S. samples (Maruskin et al., 2012). To test the hypothesis, I examined these variables in a series of multilevel regression analyses. The hypothesis was that in each analysis, a

given chills variable was regressed on a given group-mean-centered emotion variable. Slopes and intercepts were allowed to vary randomly across countries. The fixed effect (mean slope across countries) and random effect (variance of slopes across countries) from each analysis are presented in Table 3.

The fixed effects in Table 3 indicate that, on average across countries, goosetingles and coldshivers had strikingly different patterns of relations to emotions. In keeping my third hypothesis: goosetingles was positively related to all positive emotions and was unrelated to most negative emotions; coldshivers was positively related to all negative emotions and was (more weakly) negatively related or unrelated to positive emotions. Replicating and refining past studies (e.g., Campos et al., 2013; Maruskin et al., 2012), the strongest correlates of goosetingles were awe and curiosity; the strongest correlates of coldshivers were fear and anxiety. These findings speak to the universal, emotion specificity of these two sensations.

The random effects in Table 3 indicate that the emotion correlates of the two chills responses were reasonably consistent across countries. The variances of the emotion-chills slopes were modest, and some did not differ significantly from zero. Moreover, random effects are inflated by random measurement error and therefore likely overestimate the true slope variance.

Elicitors: Within-country effects

In order to test my fourth hypothesis that goosetingles and coldshivers are differentially related to positive and negative elicitors, respectively, I examined the elicitors of goosetingles and coldshivers using the same type of multilevel model used to examine emotion correlates. Fixed and random effects are presented in Table 4. The fixed effects reveal a pattern similar to that obtained in the emotion analyses.

Results indicated that goosetingles was positively related to all positive elicitors—thrill, sexual arousal, inspiration, beauty, closeness, relaxation, and success—and was more weakly related or unrelated to negative elicitors—separation, failure, and physical danger. Coldshivers was positively related to all negative elicitors and was more weakly negatively related or unrelated to positive elicitors. The elicitors most predictive of goosetingles were sexual arousal and thrill; the elicitor most predictive of coldshivers was physical danger. The random effects in Table 4 indicate that the elicitors of the two chills responses were reasonably consistent across countries. As in the emotion analyses, the variances of the elicitor-chills slopes were modest, and some did not differ significantly from zero.

Elicitors: Cross-level moderation

Next, I addressed my fifth hypothesis by testing whether the within-country effect of a given elicitor is moderated by the country's mean level of that elicitor. I hypothesized that the effect of an elicitor on goosetingles vs. coldshivers would be moderating by the mean level of that elicitor in the country such that the effect would be strongest when the elicitor was more novel. This is based on theorizing about the element of surprise in experiencing the chills (e.g., Huron, 2006). For each elicitor variable, the cross-level interaction between the latent within-country and between-country components of the elicitor were modeled using the MSEM random coefficient prediction method (Preacher, Zhang, & Zyphur, 2016). This approach avoids bias associated with use of observed means at the country level. Parameter estimates and conditional effects for countries with low (-1 SD), moderate (+0 SD), or high (+1 SD) levels of the elicitor

are presented in Table 5 (goosetingles) and Table 6 (coldshivers).

As shown in Table 5, the within-country effects of several positive elicitors (inspiration, relaxation, success, positive elicitor composite) on goosetingles were significantly attenuated in countries with higher levels of these elicitors. This indicates that the more comon a source of the chills is within a culture, the less powerfully it triggers the chills. Likewise, as shown in Table 6, the within-country effects of several negative elicitors (separation, failure, negative elicitor composite) on coldshivers were significantly attenuated in countries with higher levels of these elicitors. Moderation effects are illustrated for success and failure elicitors in Figures 1 and 2. These findings support the hypothesis that chills responses are more pronounced when the elicitor is more contextually novel, consistent with a basic orienting function of chills responses. Although not hypothesized, moderation effects opposite in sign to those discussed above were documented for the effects of negative elicitors on goosetingles and of positive elicitors on coldshivers (see Tables 5 and 6).

Thermo-social implications

Finally, I tested my sixth hypothesis regarding the social effects of goosetingles and coldshivers. The thermo-social implications of goosetingles and coldshivers sensations were investigated in two multilevel analyses. In these analyses, closeness to community was regressed on a group-mean centered chills variable. Slopes and intercepts were allowed to vary randomly across countries. Country mean temperature was grand-mean centered and modeled as a moderator of the within-country effect on closeness to community. Parameter estimates and conditional effects for countries with a cool (-1 SD), moderate (+0 SD), or warm (+1 SD) climate are presented in the top half of Table 7.

As hypothesized, goosetingles and coldshivers had opposite effects on closeness to community; goosetingles had a positive effect and coldshivers had a negative effect. The negative effect of coldshivers was moderated by country mean temperature, such that the effect was attenuated in warmer climates. This moderation effect is illustrated in Figure 3. These findings are consistent with the hypothesis that coldshivers in response to threat motivates social contact to the extent that the climate favors social thermoregulation.

It is possible that the effects of chills variables on closeness to community are spurious because both are impacted by the relational elicitors documented above (closeness, separation). To address this possibility, I repeated the thermo-social regulation analyses controlling for closeness and separation elicitors (both group-mean centered). Results are presented in the bottom half of Table 7. Although the positive main effect of goosetingles on closeness to community became marginally significant ($p = .085$) in this stringent analysis, the negative main effect of coldshivers remained significant, as did the moderating effect of country mean temperature. Although these analyses do not establish causality, they bolster the plausibility of the hypothesized causal sequence.

Discussion

The chills has long been thought to be a sensation that covaries with intense emotions. Based on earlier work that identified two distinct chills constructs—goosetingles and coldshivers—as well as their distinct profiles of elicitors and emotional associations, the present investigation provides the first empirically-derived evidence for the universality of the chills. I

asked participants in 26 countries that span 6 continents, about their experiences getting "the chills." Based on these data, I demonstrated support for my six core hypotheses regarding cross-cultural consistency in core features of chills experiences. First, I found evidence for the presence of chills experiences in these 26 diverse cultures. Second, the two-factor structure of the overall chills construct—goosetingles and coldshivers—held across cultures. Third, the emotion correlates of goosetingles and coldshivers were consistent across cultures, with goosetingles associated with approach focused emotions, and coldshivers associated with avoidance-related emotions. Fourth, elicitors of goosetingles and coldshivers were consistent across cultures—goosetingles elicited by reward-related situations; coldshivers elicited by threat-related situations. Fifth, within effects of countries, effects of particular elicitors on goosetingles and coldshivers was moderated by the mean level of that elicitor in the country, such that the effect tended to be stronger with the elicitor was less common. Finally, I replicated my previous findings regarding the social outcomes associated with each type of chills—across cultures, goosetingles were associated with social closeness and coldshivers were associated with social distance—and further that these effects are moderated by country-level mean temperature. I explain each of these key findings in more detail below.

Frequencies of chills sensations across cultures

My first hypothesis concerned the universality of the frequencies of chills sensations across cultures. Based on the intraclass correlations of goosetingles and coldshivers across cultures, I found that most of the variability in chills sensations existed within countries, rather than between countries. This indicated that individuals differ in their propensity to experience goosetingles vs. coldshivers (consistent with individual difference findings in Maruskin et al., 2012), but that these differences themselves show some consistency across cultures (hence the relative lack of between-country variance). Taken more broadly, these results provide the first evidence the chills are not culturally specific to the U.S.—people across diverse cultures report experiencing chills sensations in the response to an emotionally evocative event.

Factor structure of chills construct

My second hypothesis was that the goosetingles-coldshivers factor structure of the overall chills construct would hold across cultures. Based on a multi-level factor analysis, I found that this two-factor model had the best fit. Goosebumps and tingling comprised one factor (goosetingles); feeling cold and shivering comprised a second factor (coldshivers). Goosetingles and coldshivers were highly correlated ($r = .69$), but the two-factor model still had significantly better fit than a one-factor model. Notably, similarly high correlations were seen by Maruskin et al. (2012), especially when a narrative recall study design was used. These data indicate that, across cultures, overall chills can be broken down into distinct goosetingles-coldshivers sub-components. That is, there appears to be a universal distinction between how specific chills sensations tend to co-occur.

Emotion correlates of goosetingles and coldshivers

My third hypothesis concerned the universality of emotion correlates of goosetingles and coldshivers. As predicted, goosetingles and coldshivers were differentially related to positive and

negative emotions, respectively. Goosetingles was most strongly related to awe and curiosity, and coldshivers was most strongly related to fear and anxiety. These findings provide support for the universal emotion-specificity of chills experiences defined by different sensations—goosebumps and tingling vs. feeling cold and shivering. These findings are also consistent with my previous work regarding the emotion correlates of goosetingles and coldshivers in U.S. samples (Maruskin, et al., 2012) and build on studies of different kinds of mapping peripheral physiological response to distinct emotions.

Elicitors of goosetingles and coldshivers

My fourth hypothesis was that the elicitors of goosetingles and coldshivers would differ consistently across cultures, such that goosetingles would be elicited by positively-valenced events and coldshivers would be elicited by negatively-valenced events. I examined elicitor categories empirically derived by Maruskin et al. (2012) and I found support for this hypothesis. Goosetingles was positively related to all positive elicitors—thrill, sexual arousal, inspiration, beauty, closeness, relaxation, and success. In contrast, coldshivers was positively related to all negative elicitors—separation, failure, and physical danger. These findings are consistent with the emotion profiles of goosetingles and coldshivers (positive and negative, respectively).

Moderation by elicitor novelty

Based on theorizing that the element of surprise plays a role in chills experiences (e.g., Huron, 2006), my fifth hypothesis was that effects of a particular elicitor on experienced chills sensations would be moderated by the novelty of that elicitor in each country, such that effects would be strongest when the elicitor was more novel (i.e., was reported at lower mean levels in that country). Consistent with this hypothesis, I found that the within-country effect of a given elicitor on chills was moderated by the mean level of that elicitor in a particular country as expected. For the effects of positive elicitors on goosetingles, the effects of inspiration, relaxation, success, and a composite of all positive elicitors on goosetingles were attenuated in countries where those elicitors were more common. For the effects of negative elicitors on coldshivers, the effects of separation, failure, and a composite of all negative elicitors on coldshivers were attenuated in countries where those elicitors were more common. These findings indicate that the element of surprise may be fundamentally involved in chills experiences—whether goosetingly or coldshivery—as evidenced by the role of elicitor novelty in the prediction of chills.

Thermo-social implications of goosetingles and coldshivers

My sixth and final hypothesis concerned the social implications of goosetingles and coldshivers. As hypothesized, goosetingles and coldshivers had opposite effects on closeness to community—goosetingles was associated with increased social closeness to one's community whereas coldshivers was associated with increased social distance (i.e., decreased social closeness). These findings are consistent with previous findings regarding goosetingles, coldshivers, and closeness to one's mother (Maruskin, et al., 2012). In addition, as hypothesized, the negative effect of coldshivers on closeness was moderated by the mean country-level temperature. This is consistent with theorizing about the thermos-social function of chills—

namely that coldshivers in response to threat involves feelings of social distance that function to motivate social contact (e.g., I. I've described this as a form of "thermoregulatory outsourcing" in that we use other to help maintain our body temperature through physical closeness, so that resources needed to keep our own body warm can be allocated to managing threat.

Chills as a unique instance of embodied emotion

This research, rooted in evolutionary accounts of the relation between thermoregulation and emotion (e.g., Darwin 1872; IJzerman et al., 2015), provides evidence that the chills as a unique instance of embodied emotion that is culturally universal. Indeed, Sloboda (1995) identified the chills as an unmistakable instance of embodied emotion and broad theories of embodied emotion suggest that our bodies are closely tied to the subjective experience of emotion (e.g., Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005).

The chills can be considered a unique instance of embodied emotion in part because the construct occupies a unique conceptual space in the universe of emotion-related constructs. Emotion constructs are generally defined in terms of three core components—subjective experience, physiological correlates, and behavioral expression—that are often treated somewhat independently (e.g., Gross, 1998; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). One way in which the chills differs from other emotion-related constructs is that it occupies the intersection of these three components, rather than their uniqueness (See Figure 5). This intersection of subjective, physiological, and behavioral components may represent congruence of these three components, and as such, may be important for interoception, veridical accounts of emotion, and signaling to others—because information about the experience is derived from all three sources. Further, the chills may have received less attention than other emotion constructs in the emotion literature arbitrarily because it does not fit neatly into our traditional schema of how emotion is defined (namely, based on the independence of these three components), and may be misunderstood if forced into one of these categories.

Further, chills experiences have noteworthy physiological characteristics. First, similar to the blush (Leary et al.1992) and incipient weeping (Panksepp, 1995), chills experiences are *conspicuous* to the individual in which they occur (Sloboda, 1991). Whereas other physical responses associated with emotional arousal, such as skin conductance, occur without the awareness of the individual, chills sensations are known to the individual experiencing them and are therefore particularly adept for providing an individual with feedback about one's own emotional state. Second, chills experiences are *object focused* in that they occur because of a particular environmental elicitor and are brief and discrete. Unlike other physiological responses that are more diffuse (e.g., heart rate) the chills mark the occurrence of an emotional elicitor with accuracy. Finally, chills experiences—whether goosetingles or coldshivers—are *differentiated* in terms of valence of the associated emotional arousal. This differentiation allows veridical evidence about the nature of the eliciting situation and ultimately one's subjective experience, unlike other markers of undifferentiated arousal (e.g., skin conductance). For these reasons, chills experiences provide a fruitful avenue for further exploring the relation between physical sensations and felt emotions.

Limitations and future directions

Two limitations of this work should be noted. First, chills sensations were assessed with

self-report measures. Because it is theorized that the chills involves specific physiological changes associated with thermoregulation, an important next step will be to directly assess the physiological profile of different kinds of chills experiences, with the aim of differentiating goosetingles and coldshivers based on objective measures. Second, because of the large scope of this studies, the length of measures was limited due time required to complete the study and the complexity of the translation processes. One potential next step would be to dive deep into one or a few diverse cultures and perform a more extensive and exhaustive investigation of chills experiences. This would both bolster findings within a specific culture as well as lay the groundwork for another approach to assessing universality—that is, by examining the chills extensively in maximally different cultures (Norenzayan & Heine, 2005).

Conclusion

In conclusion, this work provides evidence that chills sensations may serve as a unique pipeline through which bodily processes associated with thermoregulation alert us to existentially important emotional events. The universality of the chills, in turn, is consistent with their roots in evolutionarily old processes. Taken together, this work supports my thesis that the chills is not a mere quirk of human of human physiology, but rather a fascinating instance of mind-body alignment that calls for additional inquiry.

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Table 1. *Sample characteristics.*

Country	Language of materials	Sample size	Percent women	Age range	Mean age
Argentina	Spanish	107	50.47	18 – 72	44.27
Australia	English	101	56.44	21 – 78	44.35
Austria	German	109	52.29	18 – 75	45.04
Brazil	Portuguese	114	50.00	18 – 74	41.38
Canada	English and French	98	51.02	18 – 82	44.57
Chile	Spanish	118	48.31	18 – 76	44.51
China	Chinese	99	53.54	22 – 70	44.46
France	French	98	54.08	19 – 71	44.10
Germany	German	107	52.34	18 – 77	45.77
India	Hindi	132	51.52	18 – 81	43.93
Indonesia	Indonesian	104	50.96	18 – 68	39.76
Ireland	English	102	51.96	19 – 70	43.69
Japan	Japanese	118	49.15	18 – 77	45.17
Mexico	Spanish	111	52.25	18 – 77	43.06
Netherlands	English	112	51.79	18 – 72	45.47
Norway	Norwegian	96	52.08	18 – 73	42.73
Russia	Russian	98	53.06	19 – 76	43.80
Singapore	English	104	48.08	18 – 75	45.77
South Africa	English	118	50.00	18 – 72	43.90
South Korea	Korean	107	52.34	18 – 72	45.39
Spain	Spanish	96	53.13	18 – 76	44.68
Sweden	English	106	51.89	18 – 88	43.91
Switzerland	German and French	109	50.46	18 – 84	44.71
Turkey	Turkish	99	54.55	18 – 67	43.41
United Kingdom	English	94	55.32	18 – 76	44.83
United States	English	104	57.69	20 – 83	45.88

Table 2. Descriptive statistics

Variable	Range	Mean	Variance		ICC
			Within-country	Between-country	
Chills variables					
Goosetingles	1.00 – 7.00	4.28	2.41	.10	.039
Coldshivers	1.00 – 7.00	4.26	2.97	.13	.040
Emotion variables					
Positive emotion	1.00 – 7.00	3.54	3.54	.12	.033
Negative emotion	1.00 – 7.00	3.03	2.49	.14	.052
Curiosity	1.00 – 7.00	3.35	4.46	.14	.031
Awe	1.00 – 7.00	3.94	5.16	.23	.042
Joy	1.00 – 7.00	3.73	6.16	.15	.024
Desire	1.00 – 7.00	2.72	4.34	.27	.058
Enthusiasm	1.00 – 7.00	3.63	5.59	.21	.036
Contentment	1.00 – 7.00	3.62	5.71	.14	.024
Happiness	1.00 – 7.00	3.87	6.21	.16	.025
Gratitude	1.00 – 7.00	3.56	5.35	.17	.031
Pride	1.00 – 7.00	3.34	5.46	.12	.022
Love	1.00 – 7.00	3.66	5.84	.16	.027
Sympathy	1.00 – 7.00	3.00	4.62	.24	.049
Surprise	1.00 – 7.00	4.08	4.36	.24	.052
Shame	1.00 – 7.00	2.23	3.41	.12	.035
Anger	1.00 – 7.00	2.66	4.45	.15	.032
Disgust	1.00 – 7.00	2.19	3.34	.19	.052
Grief	1.00 – 7.00	3.05	5.20	.24	.044
Sadness	1.00 – 7.00	3.23	5.42	.15	.027
Confusion	1.00 – 7.00	3.17	4.16	.25	.056
Anxiety	1.00 – 7.00	3.97	4.84	.35	.068
Fear	1.00 – 7.00	3.77	5.38	.21	.038
Antecedent variables					
Thrill	1.00 – 7.00	3.56	5.05	.27	.051
Sexual arousal	1.00 – 7.00	2.37	3.82	.20	.051
Inspiration	1.00 – 7.00	3.55	5.19	.10	.019
Beauty	1.00 – 7.00	3.44	5.45	.08	.015
Closeness	1.00 – 7.00	3.52	4.90	.27	.052
Relaxation	1.00 – 7.00	2.94	4.40	.13	.028
Success	1.00 – 7.00	3.43	5.26	.12	.023
Positive elicitor composite	1.00 – 7.00	3.26	2.39	.11	.043
Separation	1.00 – 7.00	2.95	4.54	.20	.043
Failure	1.00 – 7.00	2.87	4.39	.32	.069
Physical danger	1.00 – 7.00	3.14	4.93	.22	.042
Negative elicitor composite	1.00 – 7.00	2.98	2.56	.20	.071
Consequence variables					
Closeness to community	1.00 – 7.00	3.73	4.84	.08	.015
Other variables[a]					
Country mean temperature	-4.27 – 27.46	12.69		69.58	
Study order	0.00 – 1.00	.48	.25		
Gender	1.00 – 2.00	1.52	.25		

[a] MSEM could not be used to generate descriptive statistics for country temperature, for which all variance existed at the between-country level, nor for study order or gender, for which virtually all variance occurred at the within-country level. Single-level descriptive statistics are reported for these variables.

Table 3. Within-country relations between emotions and chills variables

Predictor	Goosetingles as criterion		Coldshivers as criterion	
	Mean slope (fixed effect)	Variance in slope (random effect)	Mean slope (fixed effect)	Variance in slope (random effect)
Positive emotions				
Curiosity	.14*** [.11, .18]	.005 [-.003, .013]	-.02 [-.06, .02]	.005* [.000, .009]
Awe	.13*** [.08, .17]	.007* [.001, .013]	-.01 [-.05, .04]	.006* [.000, .011]
Joy	.12*** [.07, .16]	.011** [.003, .018]	-.17*** [-.22, .-13]	.008* [.001, .015]
Desire	.12*** [.08, .15]	.003 [-.002, .008]	-.05** [-.09, -.02]	.001 [-.002, .005]
Enthusiasm	.12*** [.06, .17]	.014** [.005, .024]	-.16*** [-.21, -.12]	.007* [.001, .012]
Contentment	.12*** [.07, .16]	.012** [.003, .020]	-.17*** [-.21, -.13]	.004 [.000, .008]
Happiness	.12*** [.07, .16]	.010** [.003, .018]	-.18*** [-.22, .-14]	.006* [.001, .012]
Gratitude	.11*** [.07, .16]	.012* [.002, .021]	-.11*** [-.15, -.08]	.002 [-.001, .006]
Pride	.10*** [.06, .15]	.009* [.002, .015]	-.12*** [-.16, -.09]	.004 [-.000, .008]
Love	.10*** [.06, .13]	.005* [.000, .010]	-.08*** [-.12, -.04]	.005* [.001, .008]
Positive emotion composite	.19*** [.12, .25]	.021** [.008, .035]	-.18*** [-.23, -.13]	.009* [.000, .017]
Emotions not predominantly positive or negative				
Sympathy	.06** [.02, .09]	.003 [-.001, .006]	.01 [-.05, .08]	.02*** [.009, .030]
Surprise	.12*** [.08, .16]	.002 [-.002, .006]	.13*** [.10, .17]	.002 [-.002, .005]
Negative emotions				
Shame	.03 [-.01, .08]	.007 [-.000, .018]	.22*** [.18, .25]	.003 [-.003, .008]
Anger	-.02 [-.06, .03]	.008* [.001, .016]	.24*** [.20, .27]	.003 [-.001, .007]
Disgust	.04 [-.01, .09]	.010 [-.003, .022]	.25*** [.20, .29]	.008* [.001, .014]
Grief	-.00	.012**	.27***	.005

	[-.05, .05]	[.004, .020]	[.23, .30]	[-.000, .010]
Sadness	.00 [-.05, .05]	.014** [.004, .024]	.27*** [.24, .31]	.004* [.000, .008]
Confusion	.07** [.02, .11]	.009 [-.000, .018]	.28*** [.24, .32]	.006* [.000, .011]
Anxiety	.03 [-.02, .09]	.014* [.002, .026]	.29*** [.25, .33]	.006* [.001, .011]
Fear	.03 [-.03, .09]	.018** [.006, .029]	.31*** [.27, .34]	.004 [-.001, .009]
Negative emotion composite	.03 [-.04, .11]	.034** [.013, .056]	.49*** [.43, .55]	.013** [.005, .022]

Table 4. Within-country effects of elicitors.

Predictor	Goosetingles as criterion		Coldshivers as criterion	
	Mean slope (fixed effect)	Variance in slope (random effect)	Mean slope (fixed effect)	Variance in slope (random effect)
Positive elicitors				
Thrill	.17*** [.13, .21]	.006* [.001, .010]	.04 [-.01, .10]	.013*** [.007, .013]
Sexual arousal	.15*** [.12, .18]	.001 [-.004, .005]	.02 [-.01, .06]	.001 [-.005, .008]
Inspiration	.14*** [.11, .18]	.005 [-.002, .012]	-.05* [-.09, -.01]	.008** [.002, .014]
Beauty	.14*** [.10, .18]	.008** [.002, .014]	-.10*** [-.14, -.06]	.005 [-.001, .011]
Closeness	.14*** [.11, .17]	.002 [-.003, .006]	.02 [-.03, .06]	.007** [.002, .011]
Relaxation	.12*** [.08, .16]	.007* [.000, .014]	-.09*** [-.13, -.05]	.007* [.000, .014]
Success	.12*** [.08, .15]	.006* [.001, .012]	.03 [-.03, .08]	.014** [.005, .022]
Positive elicitor composite	.29*** [.23, .35]	.016* [.002, .030]	-.04 [-.11, .03]	.018** [.006, .031]
Negative elicitors				
Separation	.05* [.01, .10]	.009* [.001, .017]	.17*** [.12, .22]	.013** [.003, .023]
Failure	.01 [-.03, .06]	.009* [.001, .016]	.17*** [.12, .22]	.010** [.003, .018]
Physical danger	.08** [.03, .12]	.012** [.005, .019]	.25*** [.21, .28]	.004 [-.002, .009]
Negative elicitor composite	.09* [.02, .17]	.030** [.012, .048]	.34*** [.28, .41]	.020* [.002, .039]

Table 5. Interactions between latent between-country and within-country components of elicitor variables in the prediction of goosetingles

Predictor	Within-country slope				Between-country slope	Within × between interaction
	Conditional at -1 SD	Mean (+0 SD)	Conditional at +1 SD	Residual variance		
Positive elicitors						
Thrill	.15*** [.09, .21]	.16*** [.13, .20]	.18*** [.13, .23]	.005* [.000, .010]	-.35* [-.68, -.02]	.03 [-.04, .11]
Sexual arousal	.15*** [.09, .20]	.15*** [.12, .18]	.16*** [.13, .18]	.001 [-.004, .006]	-.44* [-.79, -.09]	.01 [-.05, .07]
Inspiration	.18*** [.13, .23]	.14*** [.11, .18]	.11*** [.06, .16]	.004 [-.002, .011]	-.15 [-.79, .49]	-.11* [-.21, -.01]
Beauty	.16*** [.10, .23]	.14*** [.10, .18]	.12*** [.07, .17]	.008* [.002, .014]	-.09 [-.78, .60]	-.08 [-.21, .06]
Closeness	.11*** [.07, .16]	.14*** [.11, .16]	.16*** [.12, .20]	.002 [-.003, .006]	-.04 [-.34, .27]	.05 [-.01, .10]
Relaxation	.19*** [.13, .24]	.12*** [.08, .16]	.05** [.01, .09]	.003 [-.003, .009]	-.25 [-.79, .30]	-.19*** [-.28, -.10]
Success	.15*** [.09, .22]	.12*** [.08, .15]	.08*** [.04, .11]	.005 [-.001, .011]	-.30 [-.76, .16]	-.11* [-.22, -.01]
Positive elicitor composite	.35*** [.26, .43]	.29*** [.23, .35]	.23*** [.17, .29]	.013* [.000, .026]	-.39 [-.92, .13]	-.18** [-.29, -.06]
Negative elicitors						
Separation	-.02 [-.08, .04]	.05** [.01, .09]	.12*** [.09, .16]	.003 [-.002, .008]	-.21 [-.60, .19]	.16*** [.09, .23]
Failure	-.07*** [-.11, -.03]	.01 [-.02, .04]	.09** [.04, .15]	.001 [-.002, .005]	-.14 [-.43, .16]	.15*** [.07, .25]
Physical danger	-.03 [-.07, .02]	.08*** [.04, .11]	.18*** [.12, .24]	.001 [-.003, .005]	-.36* [-.70, -.01]	.22*** [.15, .29]
Negative elicitor composite	-.08* [-.14, -.01]	.09*** [.06, .13]	.27*** [.21, .32]	.001 [-.009, .011]	-.30 [-.72, .13]	.39*** [.30, .48]

Table 6. Interactions between latent between-country and within-country components of elicitor variables in the prediction of coldshivers

Predictor	Within-country slope				Between-country slope	Within × between interaction
	Conditional at -1 SD	Mean (+0 SD)	Conditional at +1 SD	Residual variance		
Positive elicitors						
Thrill	.03 [-.07, .12]	.04 [-.01, .10]	.06 [-.02, .13]	.013*** [.006, .019]	-.11 [-.36, .15]	.029 [-.10, .16]
Sexual arousal	-.01 [-.07, .04]	.02 [-.01, .05]	.05* [.01, .09]	.001 [-.007, .008]	.12 [-.28, .52]	.07 [-.00, .15]
Inspiration	-.12*** [-.18, -.05]	-.05* [-.09, -.01]	.02 [-.04, .08]	.003 [-.002, .008]	.22 [-.37, .80]	.22** [.07, .37]
Beauty	-.16*** [-.22, -.11]	-.10*** [-.14, -.07]	-.05 [-.13, .04]	.002 [-.003, .007]	-.11 [-.60, .38]	.20 [-.01, .41]
Closeness	-.02 [-.08, .04]	.01 [-.03, .05]	.05 [-.02, .12]	.006* [.001, .010]	.10 [-.14, .35]	.07 [-.02, .16]
Relaxation	-.14*** [-.20, -.07]	-.09*** [-.13, -.05]	-.04 [-.11, .02]	.005 [-.001, .010]	.21 [-.27, .69]	.13* [.02, .24]
Success	-.05 [-.13, .02]	.03 [-.02, .07]	.10*** [.05, .16]	.008* [.001, .015]	-.22 [-.66, .22]	.22** [.08, .36]
Positive composite	-.15** [-.23, -.06]	-.04 [-.10, .01]	.06 [-.03, .15]	.008 [-.002, .018]	.02 [-.45, .49]	.32*** [.18, .46]
Negative elicitors						
Separation	.25*** [.20, .30]	.17*** [.12, .22]	.09 [-.01, .18]	.007 [-.001, .015]	.13 [-.21, .48]	-.18* [-.32, -.04]
Failure	.25*** [.19, .30]	.17*** [.13, .21]	.10* [.02, .17]	.006 [.000, .012]	-.01 [-.26, .24]	-.14** [-.22, -.05]
Physical danger	.26*** [.20, .32]	.25*** [.21, .28]	.23*** [.18, .28]	.004 [-.003, .011]	.23 [-.09, .56]	-.03 [-.12, .06]
Negative composite	.42*** [.35, .49]	.34*** [.28, .40]	.26*** [.15, .38]	.017* [.000, .033]	-.04 [-.38, .30]	-.18* [-.35, -.01]

Table 7. Prediction of closeness to community by chills sensations and moderation by country mean temperature

Predictor	Within-country effects of elicitors		Within-country effect of chills sensation				Between-country effect of temperature	Chills sensation × temperature
	Closeness	Separation	Conditional effect for cool countries (-1 SD)	Mean (+0 SD)	Conditional effect for warm countries (+1 SD)	Residual variance		
Not controlling closeness and separation elicitors								
Goosetingles			.13* [.02, .24]	.12*** [.06, .19]	.11*** [.06, .17]	.010 [-.007, .027]	.005 [-.012, .022]	-.001 [-.008, .005]
Coldshivers			-.13** [-.21, -.05]	-.07** [-.13, -.02]	-.02 [-.07, .04]	.003 [-.008, .015]	.005 [-.011, .022]	.007* [.001, .012]
Controlling closeness and separation elicitors								
Goosetingles	.28*** [.23, .33]	-.10*** [-.16, -.05]	.04 [-.06, .13]	.05 [-.01, .11]	.07** [.02, .12]	.002 [-.010, .014]	.005 [-.011, .022]	.002 [-.004, .008]
Coldshivers	.29*** [.24, .33]	-.09** [-.15, -.04]	-.10** [-.16, -.04]	-.06** [-.10, -.01]	-.01 [-.06, .04]	.001 [-.01, .01]	.005 [-.011, .022]	.005* [.000, .010]

Figures

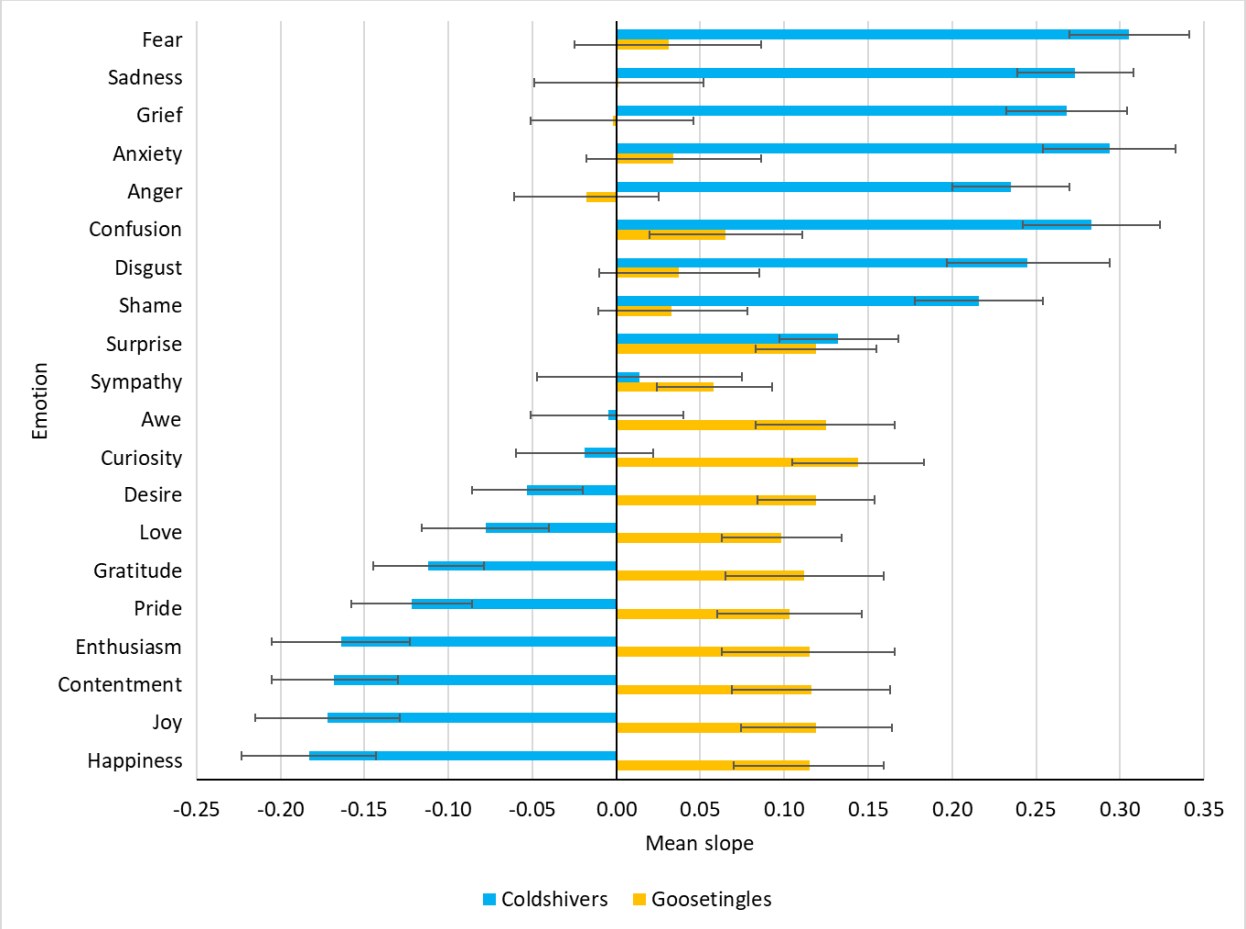

Figure 1. Mean within-country slopes relating chills sensations to emotions. Values indicate, on average across countries, the expected change in the chills sensation given a one-unit increase in the emotion. Error bars indicate 95% confidence intervals. The order in which emotions are presented is based on the difference between the coldshivers and goosetingles slopes.

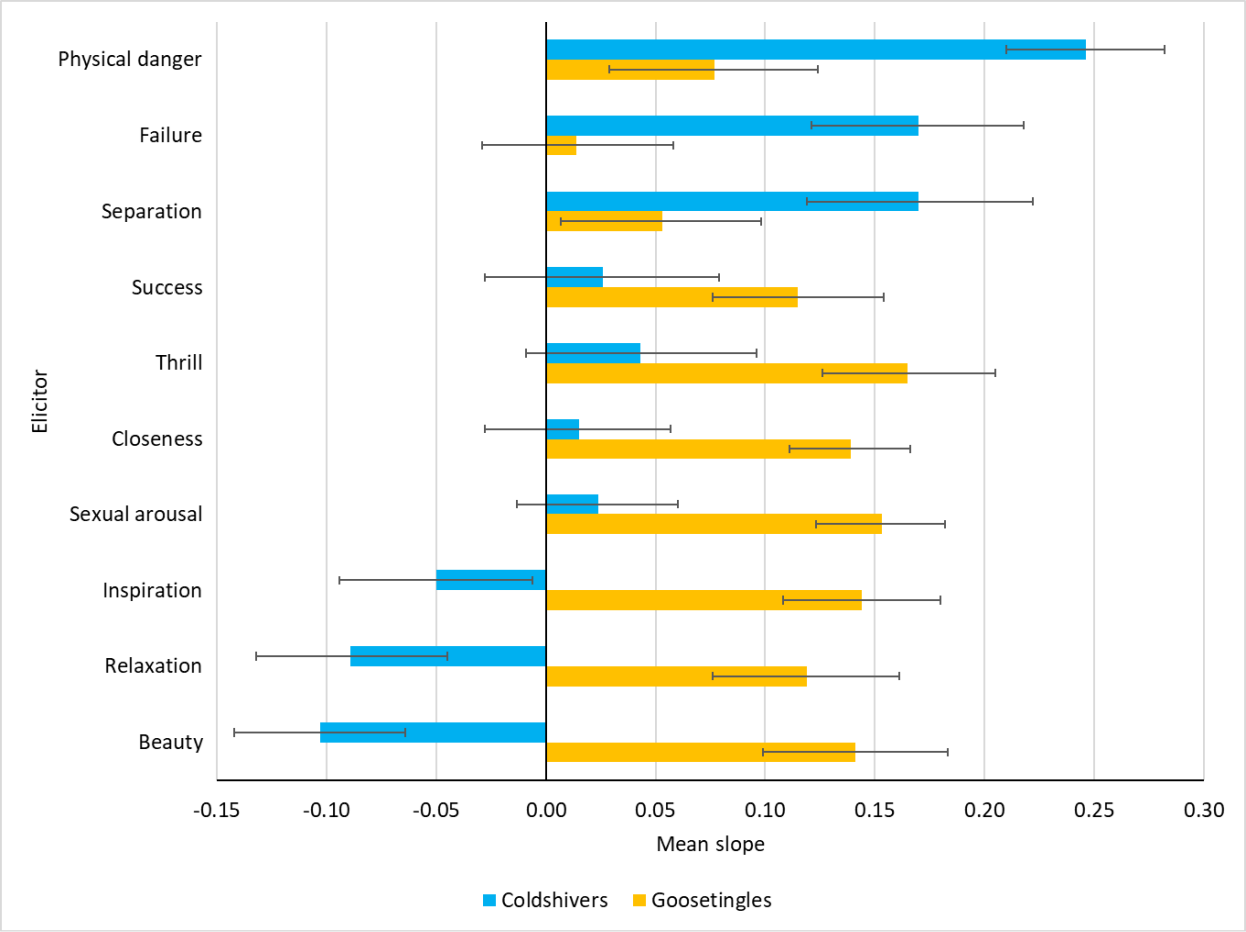

Figure 2. Mean within-country slopes relating chills sensations to elicitors. Values indicate, on average across countries, the expected change in the chills sensation given a one-unit increase in the elicitor. The order in which elicitors are presented is based on the difference between the coldshivers and goosetingles slopes.

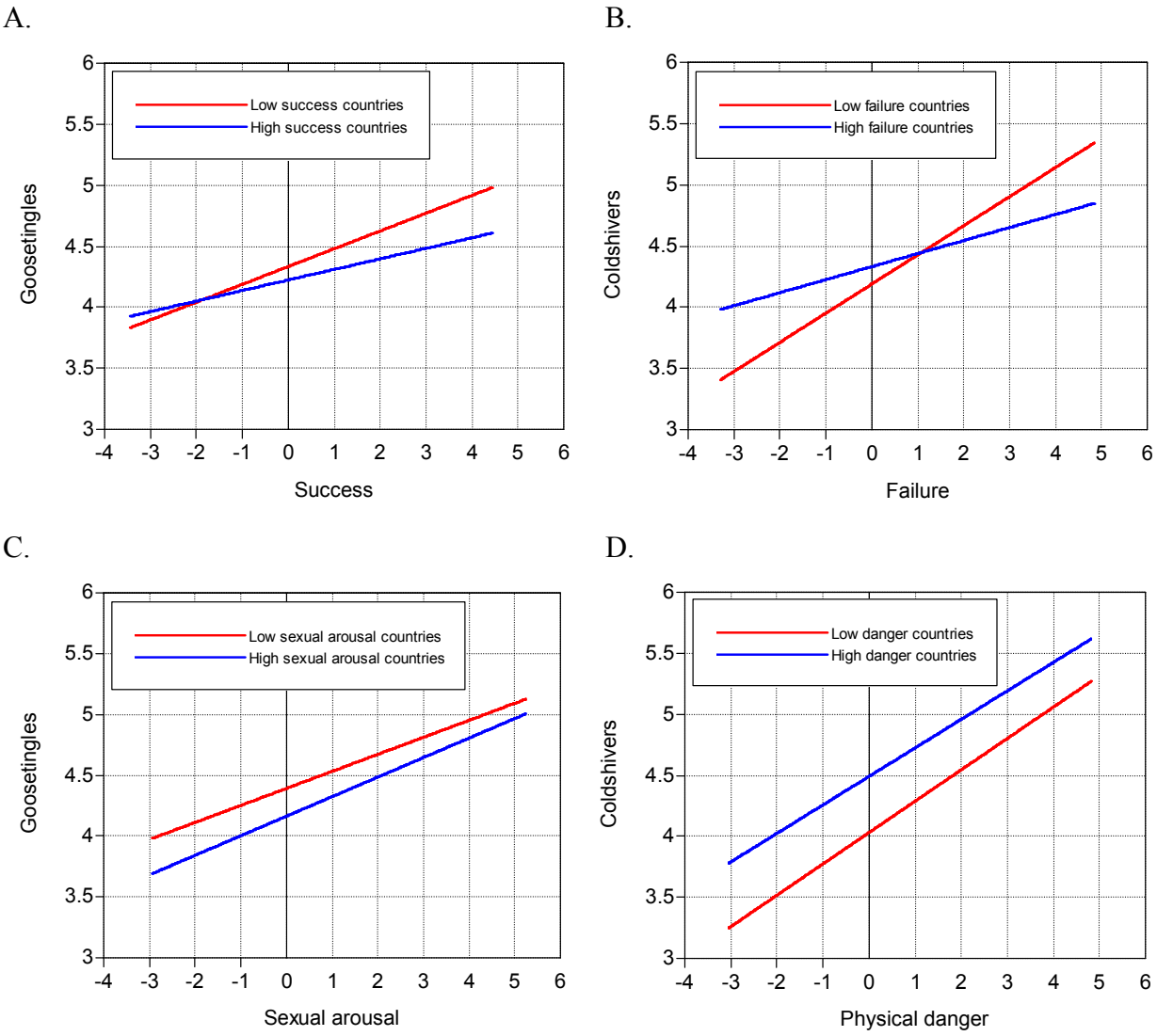

Figure 3. Effect of a given elicitor on a given chills sensation as a function of country mean levels of the elicitor. (A) Effect of success on goosetingles as a function of country mean level of the success elicitor. (B) Effect of failure on coldshivers as a function of country mean level of the failure elicitor. (C) Effect of sexual arousal on goosetingles as a function of country mean level of the sexual arousal elicitor. (D) Effect of physical danger on coldshivers as a function of country mean level of the physical danger elicitor.

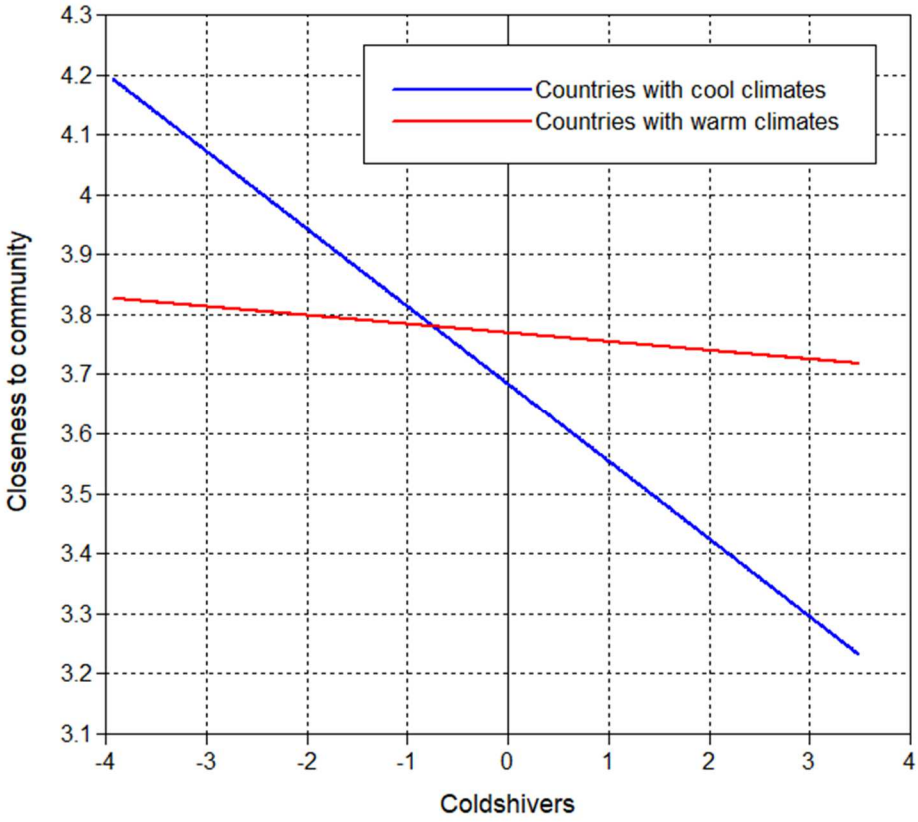

Figure 4. Effect of coldshivers on closeness to community as a function of country temperature.

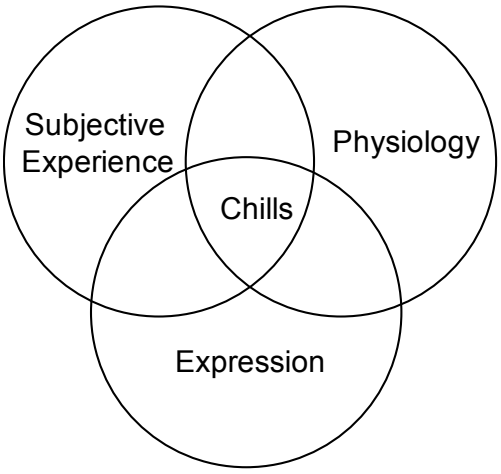

Figure 5. Conceptualization of chills in relation to classic components of emotion constructs.