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Distinguishing Between Goosebumps, Tingling, Coldness, and Shivers According to Affective Composition

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Distinguishing between Goosebumps, Tingling, Coldness, and Shivers according to Affective Composition

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COMPLIANCE PAGE

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ABSTRACT

"The chills" refers to a set of bodily sensations – goosebumps, tingling, coldness, and shivers – that accompany emotion. Maruskin, Thrash and Elliot (2012) identified two higher order clusters of chills sensations that differed in affective tone. "Goosetingles" tend to accompany positive emotions, tend to be elicited by reward-related stimuli, and enhance feelings of closeness with others. "Coldshivers" tend to accompany negative emotions, tend to be elicited by threat-related stimuli, and enhance feelings of social isolation. Factor analyses have also identified four lower order factors of chills (goosebumps, tingling, coldness, and shivers), but validity research has not established distinct nomological nets of these four sensations. The goal of this study was to test the discriminant validity of the lower order factor structure of the chills according to affective composition. Results supported my hypotheses regarding the relative locations of goosebumps, tingling, coldness, and shivers along a 12-Point Circumplex of Core Affect (Yik et al., 2011) at the Between Videos level of analysis, where goosebumps accompanied states higher on arousal, and lower on pleasure than tingling, and coldness accompanied states lower on arousal, and higher on displeasure than shivers. Reasons for an unexpected pattern of results regarding tingling at the Cell level, need to be explored in future research.

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This M.A. is dedicated to my parents who have always encouraged me to pursue my education and to Holy Spirit…

> Although we read with our minds, the seat of artistic delight is between the shoulder blades. That little shiver behind is quite certainly the highest form of emotion that humanity has attained when evolving pure art and pure science. Let us worship the spine and its tingle.
>
> - Vladimir Nabokov

"The chills" refers to a set of four bodily sensations - goosebumps, tingling, coldness, and shivering - that accompany emotion. As Vladimir Nabokov noted, experiences that evoke the chills tend to be poignant, elicited by stimuli that are regarded as important, and characteristic of emotional peaks, which can be either positive or negative in emotional tone (Maruskin, Thrash, & Elliot, 2012). Two clusters of sensations have been identified. "Goosetingles" (goosebumps and tingling) tend to accompany emotional peaks that are positive in tone, tend to be evoked by reward-related stimuli, and enhance feelings of social connection. "Coldshivers" (coldness and shivers) tend to accompany emotional peaks that are negative in tone, tend to be evoked by threat-related stimuli, and enhance feelings of social isolation. Factor analyses of the chills also identified four lower-order factors (goosebumps, tingling, coldness, and shivers), but validity research hasn't yet established distinct nomological nets of these four sensations. The present study objective is to test the discriminant validity of four lower order chills factors (goosebumps, tingling, coldness, and shivering) according to affective composition. Specifically, I aim to test how goosebumps are affectively distinct from tingling and how coldness is affectively distinct from shivering by identifying the location of the 4 chills sensations along a 12-Point Circumplex Model of Core Affect (Figure 1; Yik et al., 2011).

The Importance of the Chills

The study of chills provides an opportunity to bridge cross-disciplinary gaps in the literature. The question of why thermoregulatory mechanisms used for cold defense are also observed during significant emotional experiences is one that can be informed by a number of scientific disciplines.

The field of comparative neuroanatomy, which focuses on mapping how our neural circuitry has evolved across species and over time, found evidence suggesting that our capacity for subjective emotional experience evolved from the capacity to subjectively experience changes in temperature (Craig, 2008). This theory comes from comparative neural mapping showing that the neural circuitry that supports thermal sensations and responses was expanded upon in human primates to support affective sensations and responses (Craig, 2008).

The chills may also be of interest to evolutionary theorists. The functional utility of goosebumps, coldness, and shivering as thermoregulatory mechanisms is thoroughly understood in the literature. Goosebumps improve insulation and prevent heat loss, shivering generates heat through the involuntary contraction of skeletal muscles, and coldness motivates behavioral thermoregulatory behaviors (e.g., moving to a sunny area, huddling with conspecifics). Less is known about whether tingling arises from a thermoregulatory response. Whether chills sensations (goosebumps, tingling, coldness, shivering) that accompany certain emotional experiences serve independent functions, one core function, or possess no functional utility at all, are still unanswered questions.

Last, I propose that a developmental perspective is likely to shed light on how thermal sensations are related to emotional experience. When babies are first born, they can not self-regulate basic homeostatic processes that are necesssary for survival on their own. Maintaining a sufficient body temperature, feeding, protecting oneself from dangerous predators, and alleviating distress are all processes that must be co-regulated by the primary caregiver. In line with Harlow's (1958) classical findings, which suggest that close, physical comfort is an evolved need and the foundation by which communal relationships are built, others have emphasized the evolved need for physical warmth. Researchers have argued that the primary postnatal co-experience involves an associative pairing between maternal touch and physical warmth, which becomes the scaffold for socio-emotional development and explains the universality of metaphors linking coldness to social distance (“the cold shoulder”) and warmth to social proximity (“a warm embrace”) (Mandler, 1992; Williams, Huang, & Bargh, 2009; Lakoff & Johnson, 1999).

Incoherent Chills Literature

Inattention to factor structure in the existing chills literature has led to considerable diversity in opinion regarding the elicitors of chills, affective composition of chills, and consequences of chills sensations. The term “chills” subsumes multiple sensations (goosebumps, tingling, feeling cold, shiver-down-the-spine) but, historically, it’s been falsely assumed that the chills exist as a single, rather than multi-factor construct. Additionally, researchers have neglected to specify how they defined “chills” for participants and many have likely been measuring different constructs, but referencing them using a single term. This likely explains the inconsistencies among findings and lack of coherence in the literature.

Definition of the Chills

Maruskin et al. (2012) obtained an empirically derived definition of “chills” by asking participants which physical sensations they were referring to when they spoke about getting “the chills,” during emotionally relevant (as opposed to temperature or illness related) situations. In accordance with these results, I use the term “chills” here to refer to a set of four bodily sensations - goosebumps, tingling, coldness, and shivering - that were prevalent in individual’s descriptions of getting “the chills” in response to emotionally significant events.

Factor Structure of the Chills

Results of factor analyses by Maruskin and colleagues (2012) revealed a lower order factor structure, consisting of four distinct chills sensations (goosebumps, tingling, coldness, shivering). They also identified two higher order chills factors (“goosetingles” and “coldshivers”), which consistently aligned with approach and avoidance-related constructs, respectively. This factor structure was evidenced at both the Between and Within Person levels of analyses. Past researchers have treated the chills as a single undifferentiated construct and yielded inconsistent findings regarding elicitors, affective composition, and consequences of the chills. Maruskin and colleagues (2012) provided an explanation of previous inconsistent findings by demonstrating the discriminative validity of goosetingles and coldshivers, and have initiated progress toward a more coherent literature, and an opportunity to integrate with other fields.

Elicitors of Goosetingles and Coldshivers

Positing an approach-avoidance distinction between elicitors of goosetingles and coldshivers, Maruskin et al. (2012) asked participants to narrate an occasion in which they experience at least one of four chills sensations (goosebumps, tingling, coldness, shivers) and self-report on intensity of the chills sensation (Study 3). Positive evaluations of stimuli and approach tendencies (approach elicitors) were described with significantly greater frequency for goosetingles than for coldshivers. Negative evaluations of stimuli and avoidance tendencies (avoidance elicitors) were described with significantly greater frequency for coldshivers than for goosetingles. A follow-up daily diary study allowed them to further delineate the approach-avoidance distinction by identifying subcategories of elicitors in the narratives. Approach elicitors in general, and aesthetic beauty and sexual attraction/arousal in particular, significantly and distinctively predicted goosetingles. Other approach-related subcategories that were identified, but not distinctive to goosetingle narratives, included inspirational acts, thrills/adventure, affiliation rewards, relaxation, achievement rewards. Avoidance elicitors in general, and affiliation and achievement threats in particular, significantly and distinctively predicted coldshivers (Study 4; Maruskin et al., 2012).

Affective Composition of Goosetingles and Coldshivers

In addition to obtaining diary entries of chills experiences, Maruskin et al. (2012) asked participants to self-report on measures of affect and arousal experienced during chills inducing events. Overall, results revealed that goosetingles and coldshivers involved high arousal states. At either the Between Person level, the Within Person level, or both levels of analysis, goosetingles predicted pleasurable, highly activated states and coldshivers predicted displeasurable, highly activated states. Diary entries on goosetingles were associated with high levels of self-reported awe, surprise, enjoyment, and energetic arousal (high vigor and energy; Zajenkowski, Goryńska, & Winiewski, 2012). Coldshivers were associated with high levels of self-reported disgust, fear, sadness, surprise, and tense arousal (high tension and nervousness; Zajenkowski, Goryńska, & Winiewski, 2012).

Consequences of Goosetingles and Coldshivers

Literature on the psychosocial consequences of the chills contains inconsistent evidence and contradictory claims. Some have argued for an association between chills and separation threat in the mother-child dyad (Panksepp, 1995), or social isolation in general (IJzerman & Semin, 2010; Zhong & Leonardelli, 2008; Williams & Bargh, 2008). Other researchers have argued that the chills are associated with interpersonal closeness (Keltner; 2009). Maruskin et al. (2012) distinguished between the interpersonal consequences associated with goosetingles, and those associated with coldshivers. Their results showed that goosetingles, even while controlling for awe, positively predicted self-reported closeness to one's mother. A lower order factor, coldness, even while controlling for fear, negatively predicted self-reported closeness to one's mother.

These results reconciled two of the main findings in the existing literature, revealing different patterns for different types of chills. Coldness is associated with feeling socially isolated, while goosetingles is associated with feeling socially connected.

Present Study

Researchers have established the validity of goosetingles and coldshivers as two higher order chills factors with distinct nomological nets (Maruskin et al., 2012). Validity research establishing distinct nomological nets for each of the lower order chills sensations is a task that still remains. The purpose of the present study is to test the discriminant validity of four lower order chills factors (goosebumps, tingling, coldness, and shivering). Specifically, I aim to test whether on average, these four distinct bodily sensations tend to characteristically co-occur with distinct affective experiences.

Goosebumps, coldness, and shivering are acknowledged in the thermoregulation literature as physiologically distinct responses to the cold that serve functionally distinct roles. Goosebumps (piloerection) increases insulation and prevent heat loss, coldness motivates behavioral thermoregulation and heat gain (e.g., sunbathing, huddling behavior), and shivering is the involuntary contraction of skeletal muscles, which is a last resort attempt for our bodies to generate heat. I raise a similar question here; whether goosebumps, tingling, coldness, and shivering are psychologically distinct responses to emotional stimuli that serve functionally distinct roles.

Again, due to a history of literature that was inattentive to the possibility of a multi-factor structure of the chills, evidence on the affective states and emotional experiences that are specific to goosebump experiences, tingling experiences, coldness experiences, and shivering experiences is lacking. Historically, researchers have unknowingly been measuring qualitatively distinct chills sensations, but communicating their findings under the blanket term of "chills." Most studies have either neglected to specify a definition of "chills" for participants, or provided participants with a definition of "chills" that collapses across what Maruskin et al. (2012) have evidenced as distinct constructs ("goosetingles" and "coldshivers") with unique elicitors, affective compositions, and consequences. For example, Sloboda (1991) and Grew et al. (2007) distinguish between shivers and goosebumps in specifying a definition of the chills, but collapse across sensations in their analyses. Considered alongside evidence of a multi-factor chills structure (Maruskin et al., 2012) that demonstrates a distinct approach-related construct (goosebumps and tingling) and a distinct avoidance-related construct (composed of coldness and shivering), it becomes increasingly clear why analyses that collapse across goosebumps and shivering may produce results that are misleading.

Hypotheses

Maruskin et al. (2012) linked goosetingles with pleasing, highly activated states and coldshivers with displeasing, highly activated states. However, goosetingles decomposes into two lower order sensations (goosebumps and tingling) and coldshivers decomposes into coldness and shivers. The current study objective is to determine how goosebumps are affectively distinct from tingling and how coldness is affectively distinct from shivering by identifying the location of each sensation along a 12-Point Circumplex Model of Core Affect (see Figure 1; Yik et al., 2011).

Core Affect. Core affect is defined as "the neurophysiological state consciously accessible as the simplest raw (nonreflexive) feelings evident in moods and emotions" (Russell, 2003, p.148). Simplest feelings refers to the idea that core affect cannot be reduced any further at the psychological level. Core affect can be part of an "emotion" or part of "mood," but but not the whole of them. Core affect can be distinguished from emotion in that it is not necessarily directed at a specific object. When changing rapidly, directed at an object and accompanied by certain cognitions, physiological changes, and behaviors, core affect is a part of "emotion" (Yik et al., 2011). For example, anger and fear are sequences of subevents, and change in core affect is only one of several subevents in the sequence. Mood implies a prolonged affective experience, with behavioral demeanor, thoughts, and motivation. For example, an anxious mood implies an unpleasant, high arousal core affective state that lasts a long time and includes an increase in worrisome thoughts, vigilant behavior, and a motivation to avoid risk. Core affect doesn't include measures of duration, intensity, cognition, behavior, or motivation. Those are are treated empirically (Yik et al., 2011). Where moods and emotions can become activated and deactivated, core affect is always active. Though it may fluctuate in and out of consciousness, whenever asked, people can tell you how they feel.

Locating Chills Sensations along the 12-PAC. Figure 1 shows the 12-Point Circumplex Model of Core Affect, a pictorial representation of the underlying structure of associations among 12 core affect variables, which has been validated with empirical testing (12-PAC; Yik et al., 2011). One advantage of using a circumplex model of affect is that when testing associations with external variables, predictions are not limited to dimensions that have names in the English language. So, no dimension within affective space goes unexplored. Additionally, rather than estimate the relation between an external variable and one or two chosen affects, I can estimate the relation between an external variable and all circumplex variables at the same time, affording more data and higher statistical power (Yik et al., 2011). Another advantage of a circumplex structure of data is the ability to visually convey hypotheses regarding the magnitude and direction of associations among constructs. This allows for flexibility in precision of making predictions. Based on the lack of previous research distinguishing goosebumps, tingling, coldness, and shivers, my hypotheses refer to relative areas of the circumplex, rather than precise angles.

Goosebumps

My first hypothesis was that goosebumps would be most likely to co-occur, on average, with highly arousing and slightly pleasurable affective states.

Peak Arousal and Piloerection. Overall, piloerection has been recognized as a strong physiological indicator of an intense emotional response in both animals and humans. Darwin (1872), considered the involuntary erection of hair, feathers, and appendages, to be the most general of expressive movements among all species. Piloerection in animals has been observed during states of anger or anxiety (Darwin, 1872), internal conflict (Aureli & de Waal, 1977), predator threat (Costall et al., 1988), appetitive courtship in male chimpanzees (Nishida, 1997).

Functional theorists have argued that piloerection may have been adapted for use in psychological conditions involving threat as a social communication signal to visually warn conspecifics of a threatening situation (IJzerman et al., 2015), or as a social display of aggression to appear larger and dissuade predators from attacking (Darwin, 1872).

Affective States associated with Human Piloerection. Again, although there is a body of literature on the psychology of chills sensations in humans, far fewer have examined piloerection, specifically.

Goosebumps and Tears indicate Peak Emotional Arousal. Wassiliwizky et al. (2017) found that the climax of episodes involving the feeling of being "moved," is characterized by the overlap of goosebumps and tears occuring simultaneously. They reported that 80% of observed piloerection episodes co-occurred with lacrimation (a full-blown tears episode) and that the overlap of these phenomena signified a climatic peak in emotional arousal. This is interesting because while tear secretion is a parasympathetically mediated response, piloerection is a sympathetically mediated response. Some have argued that emotional tears function to bring about recovery and suppression of sympathetic activity (Efran & Spangler, 1979), but the findings by Wassiliwizky et al. (2017) suggest otherwise. Rather than suppressing sympathetic arousal, the parasympathetic release of tears appears to be intensifying the arousal associated with goosebumps. Sexual arousal is also a complex physiological episode involving co-activity of the parasympathetic and sympathetic systems simultaneously, within a single process (Steger & Weidner, 2011).

Piloerection as Emotional Input. Others have said piloerection may serve as emotional input, informing an intensified subjective experience (Fukushima & Kajimoto, 2012). Fukushima & Kajimoto (2012) constructed a device that artificially evokes goosebumps on the forearm through electrostatic force and tested whether a group that received artificially evoked goosebumps reported a more intense feeling of surprise during a surprise manipulation than the control group. Skin conductance responses and self-report showed that those who received artificial goosebumps experienced a more intense feeling of surprise than those who did not receive goosebumps. Therefore, goosebumps may serve as emotional input that intensifies emotional experience.

Piloerection and Feeling Moved. A small body of literature has been emerging on the experience of feeling moved or touched, an emotional state "accompanied by moist eyes, chills, thrills or gooseflesh" and exemplified by "tears shed during sentimental movies in the cinema or the flash of warmth experienced when hearing about a good deed" (Scherer & Zentner, 2001). The feeling of being moved has been evidenced as a cross-culturally expressed phenomenon that is strongly informed by heightened bodily arousal (Keuhnast et al., 2014, Menninghaus et al., 2015) and has been shown to co-occur with piloerection, specifically (e.g. Seibt et al., 2015; Benedek & Kaernbach, 2011; Strick, de Bruin, de Ruiter & Jonkers, 2015; Wassiliwizky et al., 2015). This is consistent with findings reported by Maruskin and colleagues (2012), which showed that goosetingles were often evoked while witnessing inspiring acts by others.

Piloerection and Awe. Keltner (2009) argued that although piloerection accompanied adversarial defense in our ancestors, it later evolved to accompany a feeling of primordial awe, a hard-wired response that low-status individuals felt in the presence of more powerful high-status individuals, which was adaptive in reinforcing social hierarchies (Keltner & Haidt, 2003). A daily diary study by Schurtz et al. (2012) provided support for this theory by showing that awe, and socially awe-filled experiences in particular (e.g., appreciating another person's traits, actions, performance), were the most frequently reported triggers of goosebumps, apart from the cold. These findings are consistent with findings by Maruskin et al. (2012), which demonstrated that witnessing inspiring acts was a common trigger of goosebumps and tingling.

According to Keltner and Haidt (2003), this primordial response of awe was later expanded upon to include any stimuli that induced a feeling of vastness and the need for accomodation. Other functional theorists have argued that awe may have evolved to facilitate the processing of unexpected and complex information from the environment (Shiota et al., 2014), to motivate exploration, and to build knowledge and understanding (Valdesolo et al., 2017). Together, these theories are consistent with reports by Maruskin et al. (2012) regarding frequent elicitors of goosetingles. They found that experiences involving aesthetic beauty, thrill/adventure, and achievement rewards were frequently repored as eliciting goosetingles.

Also consistent with this theory is research showing that awe can be elicited by the awesome, the awful, as well as everyday life experiences (e.g., sunlight, beautiful music, reflections on water; Gordon et al., 2017). It makes sense that if we evolved a feeling of awe to experience a feeling of vastness, to motivate exploration and accomodation, and to build upon knowledge of the environment, that we would experience awe in response to the nature because it would have been important for our ancestors to experience a fear for the unknown, while at the same time, a joyful hunger for the unexpected and the unseen. This would have been adaptive for our ancestors to learn more about and conquer their enviornments, while still possessing the evolved feeling of primordial awe in the presence of more powerful others to maintain social relationships and group cohesion.

Therefore, there is strong evidence in the literature that supports an association between piloerection and peak arousal in both animals and humans. I also expect to find that on average, the affective experiences involving goosebumps would be reported more often as pleasant, than unpleasant, which is consistent with the affective of composition of goosetingles (Maruskin et al., 2012). Two specific affective states have been found to accompany piloerection in humans: “being moved” and awe. Although both phenomenon can involve negative emotional ingredients (sadness in the case of “being moved” and fear in the case of awe), “being moved” is considered an overall pleasurable emotional state (Tokaji, 2003; Tan, 2009; Benedek and Kaernbach, 2011; Hanich et al., 2014; Menninghaus et al., 2015; Wassiliwizky et al., 2015), and individuals tend to cite positive experiences when asked to describe instances of awe (Shiota, Keltner, & Mossman, 2007). Sexual arousal is also considered a pleasurable affective state. Therefore, I predicted that goosebumps would accompany states that were slighly positive in affective tone.

Tingling

My second hypothesis was that tingling would be most likely to co-occur, on average, with highly pleasurable affective states.

Tingling and Breastfeeding. I discovered very few affective experiences involving tingling in my literature search. The most informative body of literature on the experience of tingling (that was not indicative of any underlying pathology) was research on breastfeeding. Tingling in the breast is the most frequently recalled sensation associated with breastfeeding, and specifically, with the initiation of lactation or the letdown reflex (Auerbach & Avery, 1981; Chapman & Perez-Escamilla, 1999; Hilson, Rasmussen, & Kjolhede, 2004; Hughes, 1984; Mulder, 2006; Sheldrake, 2002). In fact, breastfeeding assessments list breast tingling as one of seven phenomena that reliably demonstrates effective milk transfer is occurring (Mulford, 1992; Tobin, 1996).

One qualitative study examined the emotions that accompany breastfeeding and found that mother’s descriptions of their emotional experience depended on the physical sensations they experienced (Schmeid & Barclay,1999). Across all women, nursing was described as an embodied experience that was difficult to put into words, but central to their experience of motherhood. The physical sensations that accompanied successful breastfeeding women were described as intensely pleasurable, calming, and women often attributed these feelings to the hormones involved with lactation. Successful breastfeeders also described a positive affective experience (e.g., connected, warm, self-enhancing, intimate, relaxing). Women who were either unsuccessful or experienced disrupted lactation described unpleasurable, aggressive, and even excruciating physical sensations while attempting to breastfeed. They also described a negative affective experience (e.g., disconnected, invasive, disruptive, self-diminishing, overwhelming) (Schmeid & Barclay,1999).

The neurophysiology underlying milk production, together with self-report data on the subjective feelings that accompany this process, shed light on the affective nature of tingling sensations. The process is initiated when the infant provides sensory stimulation to the breast, which releases oxytocin into the circulation of the breast and into the brain (Uvnas-Moberg & Petersson, 2005). This activates dilation of the cutaneous blood vessels in the chest and milk is ejected or “letdown” (Eriksson, Lundeberg, & Uvnas-Moberg, 1996). Vasodilation in the mother’s chest allows heat to be transferred from mother to infant, which is evidenced by an increase in the infant’s peripheral temperature (the infant’s foot increases temperature while nursing; Uvnas-Moberg & Petersson, 2005).

The subjective experience of stress relaxation is consistent with accompanying physiological patterns that have been observed, including decreased cortisol, decreases in blood pressure, and increases in gastrointestinal activity (Uvnas-Moberg, Widstram, Marchini, & Winberg, 1987; Uvnäs-Moberg, 1996; Nilsson, 2009; Uvnas-Moberg, 1997). Indirect evidence that oxytocin release also occurs in the infant, including evidence of vasodilation and increased warmth in the infant's periphery (for a review, see Uvnas-Moberg & Petersson, 2005), suggests that the pleasurable stress-buffering effects during breastfeeding are not limited to the mother, but experienced by the mother-infant dyad (Uvnas-Moberg & Petersson, 2005). It is likely that the infant's subjective experience during breastfeeding matches that of the mother, pleasing and relaxing. Due to the shared neurophysiological underpinning of this affective experience, it is plausible that the infant experiences the same physical tingling sensation.

Therefore, there is strong evidence in the literature that supports an association between tingling and pleasure, as well as the absence of high arousal. Therefore, I predict that tingling will be located closest to the "Pleasant" vector on the 12-Point Circumplex of Core Affect Model (see Figure 2).

Coldness

My third hypothesis was that coldness would be most likely to co-occur, on average, with highly displeasing and moderately activated states.

Feeling cold has been found to be characteristic of negative emotional states including sadness, sorrow, and fear, (Breugelmans et al., 2005; Scherer, Summerfield, & Wallbott, 1983; Scherer & Wallbott, 1994). Consistent with functional theories of depression, Panksepp (1995) argued that the function of a cold chill is to motivate the initiation of social contact following separation or loss. Evidence from the literature on thermoregulation, development, and social psychology seem to support this theory.

Coldness Motivates Behavioral Thermoregulation. Feeling cold is an essential component of behavioral thermoregulation because it provides the motivational impetus to seek warmth elsewhere. Cold-blooded species rely on voluntary behavior and the external environment as their primary means of thermoregulation (e.g., turtles move from forest clearings to streams to up and down-regulate body temperature; Dubois et al., 2009; Akin, 2011). Thermal sentience, or the awareness of body temperature likely evolved as a cue to motivate voluntary behavior to either up or down-regulate one's body temperature in the most bioenergetically conservative way possible, while still managing a threshold sufficient for survival.

Warm-blooded species also use voluntary behavior to regulate body temperature (e.g., humans dress in warm layers and animal fur in the winter) and reciprocally, there is evidence to suggest that manipulating body temperature can regulate voluntary behavior. For example, one study found that applying physical warmth (e.g., holding a warm cup of tea) alleviated negative affect that occurred as a result of social exclusion (Study 2; IJzerman et al., 2012). Bargh and Shalev (2012) theorized that individuals who feel socially isolated may seek physical warmth to self-regulate their feelings of social warmth and connectedness. They found that individuals who felt socially isolated bathed/showered more frequently, for a longer duration, and preferred warmer water temperatures. Another study showed that individuals who were socially excluded desired warmer drinks on average, when compared with those who were not excluded (Zhong and Leonardelli, 2008).

Coldness Motivates Social Thermoregulation. However, solitary behavioral thermoregulation has a high bioenergetic cost. The evolution of social behavioral thermoregulatory strategies (e.g., huddling, burrow sharing) would have been selected to reduce individual cost, as well as the total net cost of thermoregulation for the group. Ebensperger (2001) reviewed hypotheses on the evolutionarily causes of group living and concluded that social thermoregulation was one of the only two well supported causes (the other was reduced risk of predation).

Social thermoregulation not only protects groups from harsh climates, but also protects young infants who haven't developed the ability to self-regulate their own body temperature (IJzerman et al., 2015). A well-known research contribution linking physical and social temperature and the importance of social thermoregulation in the context of development was that of Harry Harlow and his famous rhesus monkeys. Harlow's work suggests that physical warmth and physical comfort are evolved needs that serve as the primary scaffolding by which the rest of development depends (1958/1970). Harlow and Suomi (1970) compared the social behaviors of monkeys that received physical warmth from their mothers as infants and those that did not, and found that monkeys raised by cold surrogate mothers were significantly less affiliative and significantly less exploratory than their warm surrogate counterparts.

An association between thermal and affiliative sentience has also been detected in humans. People often describe their feelings as “warm” when they are thinking about a trustworthy and loving individual and “cold” when they are thinking about a detached, distant individual (Asch, 1946; Fiske et al., 2007; IJzerman and Semin, 2010). Ijzerman and Semin (2009) found that participants seated in a warm room reported feeling interpersonally closer to the experimenter compared to participants seated in a colder room.

Other studies have evidenced a relation between thermal sensations and feelings regarding group affiliation. One study found that individuals who felt excluded perceived the physical temperature of the room as colder than those who were not excluded (Zhong & Leonardelli, 2008). Another study found that being excluded in an online ball tossing game led to lower finger temperatures (Study 1; IJzerman et al., 2012). Consistent with these findings, Maruskin et al. (2012) reported that coldshivers negatively predicted closeness to an attachment figure, and that this negative relationship was attributable specifically to coldness, and not to shivers.

Therefore, there is strong evidence in the literature that supports an association between coldness and displeasure, but the evidence regarding activation is mixed. Feeling cold has been found to be characteristic of both activated and deactivated negative states including sadness, sorrow, and fear (Breugelmans et al., 2005; Scherer, Summerfield, & Wallbott, 1983; Scherer

Scherer & Wallbott, 1994). Therefore, I predict that coldness will be located at a position of high displeasure, but lower on the arousal than shivering, and lower on arousal than coldshivers (see Figure 2). This position is best represented by the affective space that falls between the vectors labelled "Activated Displeasure" and "Displeasure" on the 12-Point Circumplex of Core Affect Model (Figure 2).

Shivers

My fourth hypothesis was that shivering would be most likely to co-occur, on average, with highly arousing and highly unpleasurable affective states.

Shivering and Fear. Shivering may be associated with fear-related states. A study on the psychobiology of stage fright by Fredrikson and Gunnarsson (1992) found that performance related tremors were associated with high performance anxiety and elevated heart rate, which is linearly related to fear ratings in fear-provoking situations (Lang, Melamed, & Hart, 1970; Sartory, Rachman, & Grey, 1977). Other studies have associated shivers with fright and sorrow (Lange, 1885/1922), the sudden awareness of one's mortality (Erikson, 1958; Leveton, 1965), emotional excitement (Darwin, 1872) and tension or excitement (Cattell & Scheir, 1958).

Shivering and Disgust. Shivering may also be associated with disgust-related experiences. A recent study by Blake et al. (2017) identified the unique elicitors, bodily sensations, and behavioral consequences that distinguish fear from disgust, and a subclass of disgust referred to as the "heebie jeebies," which is related, but distinct from fear and disgust. Shivering and the urge to shake were frequent behavioral responses to all three of these highly arousing negative states.

Fear was elicited by physical danger, including animal threats, human threats, natural threats, and situational threats. Disgust was elicited by contamination-related stimuli (e.g., injury, illness, death, bodily fluids or blood, spoiled food, dirty things and people, aversive smells and nonskin disease). The heebie jeebies were elicited by skin barrier threats or skin-transmitted pathogen stimuli (e.g., parasites, spiders, roaches, other insects, skin conditions, textures and clusters resembling skin related conditions, and the supernatural).

Blake et al. (2017) experimentally mannipulated elicitors of fear, disgust, and heebie jeebies and reported on the associated behavioral responses and urges in each condition. Shivering occurred most frequently during the fear condition, which featured a car skidding out of control along a rainy highway. “The urge to shake things off” occurred frequently in both the disgust condition (featuring someone touching dog feces) and the “heebie jeebie” conditions (featuring a large wolf spider moving with a pod of live crawling spider babies on its back, a dark encounter with a ghost in an elevator, and someone viewing another person’s bumpy, flaky skin rash).

Shivering may have evolved as a behavioral response to pathogen disgust, the first lines of defense in the body’s behavioral immune system, which evolved to protect the body from the risk of disease (Curtis, Aunger, & Rabie, 2004; Oaten, Stevensen, & Case, 2009; Tybur & Lieberman, 2016). Stimuli that elicited “heebie jeebies” resulted in itchy, skin-crawling sensations and behavioral urges to shake things off the skin. “Heebie jeebies” may be accompanied by shivering and body-shakes to rid the skin of potential threats and avoid skin-transmitted pathogens. Together, these findings are consistent with Maruskin et al. (2012), who reported that relative to goosetingles, coldshivers were uniquely related to disgust, fear, sadness, and tense arousal and elicited more generally by avoidance-related stimuli.

Functional Utility of Shivering. Goodman and Kelso (1983) found a systematic relationship between initiation of limb movement and physiological tremor and posited that tremors evolved to exploit intrinsic oscillation and reduce the energy demands of initiating and controlling limb movement. They explain that when a system in continuous oscillation is provided with an appropriately phased forcing function, less energy is required to move the system than when it is in static equilibrium. Under certain conditions, humans may use tremors to enhance motor performance.

Therefore, there is strong evidence in the literature that supports an association between shivers and highly displeasing, high arousal states. I predict that shivers will be placed closest to the “Unpleasant Activation” vector on the 12-Point Circumplex of Core Affect Model (see Figure 2).

Method

Participants

Participants were 159 introductory psychology students from a U.S. university who participated in order to fulfill a research participation requirement. Data from one participant was excluded from analysis because he or she requested to withdraw from the study after 2 of 14 stimuli were presented. The final sample consisted of 158 participants (91 men, 67 women). Mean age was 18.80 years (range 18 – 23 years).

Procedure

Participants attended individual sessions in the laboratory in which they watched a series of video clips (n=14 videos). Following each video clip, participants self-reported on measures of chills and affect. The order in which videos were presented was randomized for each participant. Table 1 includes sample characteristics of the videos, including descriptions of video content and video durations.

Measures

Internal consistencies for each variable are reported in Table 2.

Chills Sensations. Intensities of the four chills sensations were assessed using the state version of the Chills Questionnaire (Maruskin, Thrash & Elliot, 2012; study 2). Following each video, participants rated the extent to which they experienced goosebumps ("felt hairs stand-on-end somewhere on my body," "got goosebumps," "felt hairs stand on end"), tingling ("felt tingling sensations in my skin," "felt tickling sensations somewhere in my body," "felt a tingling sensation spread over me"), coldness ("got a cold feeling," "got a cold sensation deep inside me," "got a cold feeling at my core"), and shivers ("felt my muscles quiver or tremble," "felt myself shudder," "felt myself shiver or shake") on a scale from 1 (*not at all*) to 7 (*very strongly*).

Circumplex Affect. Affective experience was assessed using an abbreviated version of the adjective-based 12-Point Affect Circumplex Scale (12-PAC; Yik, Russell, & Steiger, 2011). This scale has been shown to be both valid and reliable for current and remembered moments. Participants rated the extent to which they felt each of 12 different core affects during the preceding video. Participants rated each item on a scale from 1 (*not at all*) to 5 (*extremely*). In order to minimize participant burden in a repeated measures design, 2-3 adjective-based items from a given angle of the 12-PAC were combined to form a single-item indicator of core affect at that angle. The twelve core affective states in the circumplex measure included pleasant (0°; “happy, content, pleased”), activated pleasure (30°; “enthusiastic, proud, euphoric”), pleasant activation (60°; “energetic, alert, excited”), activated (90°; “aroused, hyperactivated, intense”), unpleasant activation (120°; “anxious, jittery, nervous”), activated displeasure (150°; “tense, agitated, fearful”), unpleasant (180°; “unhappy, troubled, miserable”), deactivated displeasure (210°; “gloomy, sad, down”), unpleasant deactivation (240°; “tired, sluggish, dull”), deactivated (270°; “quiet, still”), pleasant deactivation (300°; “calm, relaxed, at rest”), deactivated pleasure (330°; “soothed, peaceful, at ease”).

Data Structure

The unique nesting structure of the data is illustrated in Figure 3. My design involved crossing a sample of participants (n=158) with a sample of (n=13; *Hot Cross Buns* was the neutral video and was excluded from analyses) videos. Each person watched each video, yielding data for a total of 2,054 person × video cells. Because each participant watched the same 14 videos, participant responses are not independent from one another. Participant responses are nested within a given video. Additionally, responses regarding bodily sensations and affect are common to an individual, who responds to all video stimuli in a way that is common to them as an individual. Therefore, responses across videos are not independent, but rather, participant responses are nested within a given person. Due to this crossed nesting structure of the data, I utilized a cross-classified multilevel model, which was chosen based on several of its associated strengths (Raudenbush & Bryk, 2002).

Using standard multiple regression to analyze nested data violates the assumption of independence. Consequences of violating this assumption include downwardly biased estimates of standard errors, leading to highly inflated Type I error rates, and inaccurate significant tests (Raudenbush & Bryk, 2002). Cross-classified modeling accounts for non-independent observations by separating what are independent levels of analysis (Between Person level, Between Video level, Cell level; see Figure 3), and a complex error structure that cannot be modelled using multiple regression or HLM. Using this technique ensures accurate estimates of parameters and significance tests.

Additionally, this technique affords generalizability. By modeling random variability at both the video and person levels, the results may be expected to generalize beyond the current samples of videos and persons to the populations from which they were drawn. This is yet another strength that is not afforded by traditional statistical techniques. Without modeling effects as random, results of any single analysis do not generalize beyond the specific set of stimuli that were used in that particular study (Judd, Westfall, & Kenny, 2012).

Data Preparation

For chills sensations and circumplex affect variables, the mode also tended to be the minimum. This type of severe skew is not surprising, because not all people are affected emotionally by every video. Accordingly, the distributions were dichotomized and modelled as binary in Mplus.

The data were decomposed into three orthogonal levels of analysis (see Figure 3): two upper levels (Between Person Level, Between Video Level) and one lower level (Cell Level). At the Between Person level, any variance explained in the outcome variable (e.g., circumplex affect) attributable to a predictor variable measured at the Between Person level (e.g., Goosebumps, Tingling, Coldness, Shivers) is due to differences between individuals. At the Between Video level, any variance explained in the outcome variable (e.g., circumplex affect) attributable to a predictor variable measured at the Between Video level (e.g., Goosebumps, Tingling, Coldness, Shivers) is due to differences between videos. At the Cell level, any variance explained in the outcome variable (e.g., circumplex affect) attributable to a variable measured at the Cell level (e.g., Goosebumps, Tingling, Coldness, Shivers) is residual variance not explained by person or video effects. This third level encompasses Video × Person interaction variance and within-cell error variance. Video × Person interaction variance is variance due to the unique person-video pairing, and within-cell error variance is variance within each Video × Person cell. However, because each person only watched each video once, the current design involves one observation per cell, and therefore it is not possible to disentangle Video × Person interaction variance from within-cell error variance. Accordingly, I use the general term "cell level" here and refer to any variance that is not accounted for by the average effect of Person and the average effect of Video.

Analyses were conducted in Mplus 8.0 (Muthén & Muthén, 2012) using Bayesian estimation due to the complexity of cross-classified multilevel data (Muthén, 2010). All analyses were repeated setting the minimum number of iterations to four times the number of iterations from the initial analysis to minimize premature model convergence (Muthén & Asparouhov, 2012).

The Cosine Method: Locating Goosebumps, Tingling, Coldness, and Shivers along a 12-Point Circumplex of Core Affect. The study objective was to estimate the relative locations of goosebumps, tingling, coldness and shivers along a 12-Point Circumplex Model of Core Affect (figure 2; Yik et al., 2011). Not all external variables are related to core affect, and therefore, not all variables can be located along the 12-PAC (Yik et al., 2011). However, if an external variable is related to core affect, the correlations between the 12 Core Affect variables and the external variable should form a cosine curve. Therefore, I tested whether the pattern of correlations between the 12 circumplex affect variables and the 4 chills sensations (separately at each of the 3 levels of analysis; see Table 3) formed a cosine curve to determine whether the chills were related to core affect (R^2 = variance explained by the cosine curve). Then, using the Cosine Wave Technique (Yik et al., 2011; see Appendix A; M. Yik, personal correspondence, April 2, 2018), I obtained precise estimates of the locations of goosebumps, tingling, coldness, and shivers in the 12-PAC circumplex space (â = circumplex angle in degrees). I also obtained estimates of the magnitude of the relation of each chills sensation with its identified location (r_{max} = magnitude of the relation with that angle of the circumplex).

Results and Discussion

Descriptive statistics for chills sensations and circumplex affect are shown in Table 2, and correlation matrices separated by the level of analysis are shown in Table 3. Detailed results of the Cosine Method Analyses are shown in Table 4.

Between Person Level

The pattern of relations between circumplex affect and goosebumps, tingling, coldness, and shivers at the Between Persons level are plotted in Figures 4 – 7, respectively. R^2 is a measure of the variance explained by the cosine curve. The pattern of correlations for all four chills sensations showed good fit with the cosine curve (goosebumps, R^2 = .68; tingling, R^2 = .78; coldness, R^2 =.74; shivers, R^2 =.55), indicating a robust relationship with core affect. Correlations between all circumplex affect variables and all four chills sensations revealed an overall positive relationship (see Table 3). Specifically, results of the cosine method analyses located all four chills sensations between pleasant activation and activation on the 12-Point Circumplex Model of Core Affect; goosebumps (â =81.70º; r_{max} =.63), tingling (â =91.19º; r_{max} =.69), coldness (â =54.49º; r_{max} =.53), and shivers (â =94.57º; r_{max} =.60).

The pattern of results revealed at the Between Persons level of analysis were inconsistent with my predictions, but not surprising. The Between Persons level of analysis answers the question of whether certain people who tend to report certain chills (e.g., tingling), also tend to report certain core affective experiences (e.g., pleasant activation). Correlations between all circumplex affect variables and all four chills sensations at the Between Persons Level revealed strong positive relations across the board (see Table 3). Results of the cosine method analyses located all four chills sensations between pleasant activation and activation on the 12-Point Circumplex Model of Core Affect. In other words, people who tend to report goosebumps, tingling, coldness, and shivers also tend to report highly activated, highly pleasant states. It is plausible that these results reflect the effect of an individual response style that involves a willingness to self-report a phenomenon happening or the tendency to endorse things while self-reporting. This highlights the advantage of decomposing the crossed nested data structure into 3 independent levels of analysis. By removing individual differences in response style from the total predictable variance at the Between Videos level of analysis and Cell level of analysis, I obtained more accurate estimates of my parameters.

However, I caution the reader in their interpretation of these results by pointing out that there was very little variance at the Between Person Level (see Table 2). Therefore, although results reveal a possible effect of individual response style, patterns of association hardly varied across people, limiting the

the extent to which the average effect of the Person can influence the overall association between affect and chills.

Between Video Level

The pattern of relations between circumplex affect and goosebumps, tingling, coldness, and shivers at the Between Videos level are plotted in Figures 8 – 11, respectively. The pattern of correlations for all four chills sensations showed good fit with the cosine curve (goosebumps; R^2 = .52), (tingling; R^2 = .94), (coldness; R^2 =.95), (shivers; R^2 =.94), indicating a relationship with core affect. Results at the Between Videos Level of analysis answers the question of whether videos that tend to elicit certain types of chills (e.g., goosebumps), also tend to elicit certain affective states (e.g., activation).

Goosebumps. Results of the cosine method analysis revealed videos that elicited goosebumps also tended to elicit a specific state of core affect best characterized by the peak of the curve at 143.10º in the 12-PAC (â = 143.10). I hypothesized that videos that tended to elicit goosebumps would also tend to elicit slightly pleasant, highly activated states. As expected, goosebumps were associated with highly activated states, (see Figure 2). However, contrary to my predictions, on average, videos that elicited goosebumps tended to elicit unpleasant, rather than pleasant affective states (see Figure 17). The magnitude of the association between goosebumps and the vector at 143.10 is estimated at r_{max} =.15, which identified goosebumps as least related to a unique position on the circumplex, and therefore least related to core affect (Yik et al., 2011).

Together, these results may reflect the fact that goosebumps accompanies a wide range of angles along the circumplex, explaining why goosebumps show the smallest association with a particular angle along the circumplex. This is also not inconsistent with previous research, which has linked piloerection with unpleasant activated states in animals including anger, fear (Darwin, 1872), internal conflict (Aureli & de Waal, 1977), and predator threat (Costall et al., 1988), as well as pleasant activated states, including appetitive courtship in male chimpanzees (Nishida, 1997), and in states of awe, feeling “moved” (Seibt et al., 2015; Benedek & Kaernbach, 2011; Strick, de Bruin, de Ruiter & Jonkers, 2015; Wassiliwizky et al., 2015), and surprise In humans (Fukushima & Kajimoto, 2012). Although previous researchers have argued that humans tend to describe positive events when asked to recall states of “feeling moved” and awe (Shiota, Keltner, & Mossman, 2007; Tokaji, 2003; Tan, 2009; Benedek and Kaernbach, 2011; Hanich et al., 2014; Menninghaus et al., 2015; Wassiliwizky et al., 2015), the present study differs from these in that affective states were recalled following experimental manipulation of video stimuli, rather than narrative recall. It is likely that consistent with the present results and Darwin’s (1872) observation, piloerection represents a general expression of arousal, and can take on affective states that are both positive and negative affective tone.

Tingling. Based on evidence linking tingling during breastfeeding with pleasure, social warmth, and stress buffering effects (Schmeid & Barclay,1999; Uvnas-Moberg & Petersson, 2005) I predicted that tingling would, on average, accompany highly pleasant, but low activation states (see Figure 2). Results indicated that videos that tended to elicit tingling also tended to elicit a specific state of core affect best characterized by the peak of the curve at 6.59º in the 12-PAC (â = 6.59). The magnitude of the association between tingling and the vector at 6.59º is estimated at r_{max} = .81.

These results evidenced tingling as distinct from goosebumps, on the basis of association with low activation and highly pleasing affective states (see Figure 17). The link between tingling and breastfeeding as an embodied, intimate, and pleasing dyadic experience (in both the physical and affective sense of the term) evidences adaptations afforded by the development of the mammalian caregiving system (Porges, 2001). With the evolution of homeotherms and later, mammals, there was a huge increase in caregiving responsibilities, which came at a high bioenergetic cost. The mammalian vagus evolved as an expansion of the autonomic nervous system in vertebrates to significantly reduce the expense of mammalian caregiving by developing a capacity for social engagement and disengagement (Porges, 2001). This is evidenced by the neuroanatomical link between the mammalian vagus and cranial nerves that regulate muscles required for nursing infants, including facial muscles (emotional expression), muscles of mastication (e.g., ingesting breastmilk), head-turning muscles (e.g., hunger cues, social gesture and orientation), laryngeal and phayngeal muscles (e.g., separation calls, vocalization and language; Porges, 2001). This social engagement system is intimately related to stress reactivity and neurophysiologially interconnected with the HPA axis and oxytocin release (which also regulates the release of breastmilk and causes tingling). The present results which show a highly pleasant, deactivated state during tingling is consist with activation of the mammalian vagal brake, which functions to inhibit the sympathetic nervous system and the stress response, and allow social engagement without fear (Porges, 2001).

Coldness. Videos that elicited coldness also tended to elicit a specific state of core affect best characterized by the peak of the curve at 174.33º in the 12-PAC (â = 174.33). The magnitude of the association between coldness and the vector at 174.33º is estimated at r_{max} = 1.09.

Previous research links the absence of physical warmth with the absence of socially warm experiences (Harlow & Suoimi, 1970) and low body temperatures with social exclusion and isolation (Zhong & Leonardelli, 2008). Results were consistent with my hypotheses, revealing that videos that elicited coldness also tended to elicit highly displeasing, activated experiences, distinguishing coldness from shivering on the basis of low arousal (see Figure 17).

In the ancient world, a mother's failure to maintain close proximity with an infant would have meant an inability to provide physical warmth (feeling cold), a danger, which if unmanaged may become a threat to infant survival. Therefore, consistent with Panksepp's (1995) theory, if a cold chill functions as a separation call to signal distress, and motivate social proximity with a caregiver, then the capacity to feel cold would be considered an adaptation. This is consistent with Porges' (2001) theory on the function of the social engagement system, being to conserve energy by adapting other ways to respond without activating the sympathetic nervous system. Feeling cold may activate a social alarm system, activated by activation of the mammalian vagus to motivate social proximity as a low cost method of alleviating distress, in comparison to a full-blown sympathetic response (Porges, 2001). This is consistent with the present results, which show coldness tended to accompany low-moderate, rather than high arousal states.

Shivers. Videos that elicited shivering also tended to elicit a specific state of core affect best characterized by the peak of the curve at 160.52º in the 12-PAC (â = 160.52º). The magnitude of the association between shivers and the vector at 160.52º is estimated at r_{max} = 1.03. As predicted, shivering tended to accompany highly displeasing, activated states, distinguishing shivering from coldness on the basis of high arousal (see Figure 17).

The proposition that shivering may have evolved to initiate limb movement and enhance motor performance (Goodman & Kelso, 1983) is consistent with studies linking shivers with both fear and skin-related pathogen disgust and with results of the current study. Rapid mobilization of the limbs is adaptive for both predator escape and quick removal of skin-related pathogens. It is also considered an adaptation of the ventral vagal complex, a subsystem of the parasympathetic nervous system that evolved in mammals and is known to serve a mobilization function, separate from that of the sympathetic nervous system (Porges, 2001). The vagus serves as a vagal brake, or restraint, but when vagal tone is removed, it enables rapid mobilization of energy in times of stress (fight/flight) without having to engage the sympathetic nervous system, which comes at a much higher bioenergetic cost (Porges, 2001). This is consistent with the thermoregulation literature, which indicates that unlike piloerection, shivering is not mediated by the sympathetic nervous system (Romanovsky, 2007).

Cell Level

The pattern of relations between circumplex affect and goosebumps, tingling, coldness, and shivers at the Cell level are plotted in Figures 12 – 15, respectively. The pattern of correlations for all four chills sensations showed good fit with the cosine curve (goosebumps; R^2 = .82), (tingling; R^2 = .73), (coldness; R^2 =.95), (shivers; R^2 =.89), indicating a relationship with core affect. Results of the cosine method at the cell level of analysis placed goosebumps, tingling, coldness, and shivering in the same positions as expected relative to one another (see Figure 18), but not relative to precise angles of the circumplex itself (see Figure 2). Precise placements along the 12-PAC at the Cell level of analysis were as follows: goosebumps (â =118.87º; r_{max} =.12), tingling (â =110.90º; r_{max} =.10), coldness (â =169.69º; r_{max} =.15), and shivers (â =128.09º º; r_{max} =.14).

The Cell level of analysis accounts for residual variance, picking up on effects that reflect a unique interaction between videos and people and the movement of variables together, and anything beyond what I would expect based on the average effect of the video or the average effect of the person. Results at this level of analysis showed an unexpected shift in the location of tingles along the circumplex, from highly pleasing and low activation to highly displeasing and high activation.

It is possible that this unexpected pattern of results at the cell level is picking up on a meaningful Person x Video interaction that is causing the affective pattern for tingling to deviate from what I expected. While results at the cell level reveal a larger dissociation between shivering and coldness on the dimension of arousal than at the Between Videos level, it would not be unordinary for this deviation to be a result of chance. However, it seems unlikely for tingling to migrate from a highly pleasing deactivated state to a highly activated displeasing state by chance alone. These results point to the idea that there may be a certain group of people who, when watching certain videos, experience a highly activated state of displeasure that is accompanied by tingling. However, further research will be required to determine whether there is an interesting phenomenon to be discovered because the current study consisted of single observations at the cell level. Therefore, it was impossible to dissociate Person x Video level variance from within-cell error variance, and impossible to make inferences about a Person x Video interaction.

General Discussion

Limitations

A few limitations of this study should be noted. First, although I was able to decompose goosetingles into goosebumps and tingling, and plot their relative positions along the 12-PAC with indices of cosine curve fit, I did not directly compare whether goosebumps was statistically significantly different from tingling on the dimension of activation or pleasure. Similarly, although I was able to decompose coldshivers into coldness and shivers and plot the relative positions, I did not directly compare whether shivering was statistically independent from coldness on the dimension of activation or displeasure. However, one redeeming strength of a Circumplex structure is the reliability of estimates due to the fact that placement along the Circumplex reflects a consistent pattern of correlations among multiple variables, rather than a single point estimate.

Additionally, because the present study relied on self-report, it is unclear whether distinct subjective experiences correspond to distinct objective phenomena. This remains an open and interesting question for future research.

Closing Remarks and Future Research

Results of the present study showed that there are four distinct chills sensations (goosebumps, tingling, coldness, and shivers) that tend to co-occur with distinct core affective experiences. At the Between Person level of analysis, people who tended to endorse chills sensations, also tended to endorse highly activated, highly pleasant states. However, because of the small amount of variance at the Between Person level, these results are to be interpreted with caution.

At the Between Videos level of analysis, results placed the four chills sensations at expected locations along a Circumplex model of affect (Yik et al., 2011). Goosetingles dissociated into goosebumps and tingling, which were distinguished according to both valence and arousal. Videos that tended to elicit tingling also tended to elicit highly pleasing, deactivated states, while videos that tended to elicit goosebumps also tended to elicit highly activated, slightly displeasing states. Coldshivers dissociated into coldness and shivering, which were distinguished according to arousal. Videos that tended to elicit coldness and shivering also tended to elicit displeasing states, but videos that tended to elicit shivering also tended to elicit higher activation states than those that tended to elicit coldness.

Further research is required to explore the interesting pattern of results for tingles that occurred at the Cell Level of analysis. Variance in tingling that was not accounted for by the average effect of Persons or the average effect of Videos was associated with variance in high activated states of displeasure that were not accounted for by the average effect of Persons or the average effect of Videos. Whether this reflects a Person x Video interaction, such that for certain people watching certain videos, tingling co-occurred with a highly activated and displeasing state or is simply the result of chance will require further research. However, reflecting on these results post-hoc, tingling does appear unique in that it may be the only one of the four chillss sensations that would be expected to vary in affective composition depending on the person's early childhood experiences. I speculate that goosebumps may be a general marker of sympathetically mediated arousal (Romanovsky, 2007), which functions to rapidly mobilize energy (at a high cost) and that I would expect to be consistent across individuals. I speculate that shivering, may be a marker of parasympathetically mediated arousal (Porges, 2001), that functions to rapidly mobilize energy (at a lower cost) and that I would also expect to be consistent across individuals. I speculate that coldness, which may be a general marker of distress and functions to motivate social proximity seeking (at an even lower cost), would also be expected to remain consistent across individuals. However, I speculate that the affective composition of tingling may be different from the other four sensations in that the tingling experience is dependent on the individual's early childhood experience with the primary caregiver. Therefore, an infant with a secure attachment to a warm, intimate, stress-buffering mom may experience the tingling that accompanies breastfeeding as warm, intimate, and stress buffering. An infant with an insecure attachment to a cold, distant, stress-inducing mom may experience tingling as cold, distant, and stress inducing (Uvnas-Moberg & Petersson, 2005). Although the mammalian vagus evolved to assist the mother-infant dyad by fostering social engagement and disengagement, the development of the mammalian vagal brake is entirely dependent on the early attachment experience (Porges, 2001), which is expected to differ across individuals. Further research will be required to determine whether the unexpected pattern of results at the Cell level is reflecting a subgroup of insecurely attached individuals.

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Table 1

Sample Characteristics of Eliciting Stimuli

Video	Description	Duration (minutes)
Susan Boyle	On Britain's Got Talent, Susan Boyle offers a moving vocal performance that exceeds the expectations of the judges and audience.	2.59
Soldier's Reunion	A compilation of home footage of soldiers coming home from abroad and surprising their loved ones.	2.29
Lion King	Final scene from the Lion King following Simba's victory over the kingdom of darkness, and his redemption of the kingdom of light. The scene ends as the animal kingdom bows down in honor of their future king, Simba's newborn son.	2.35
Miracle	Scene from Miracle featuring the last minutes of the United State's miracle victory over the invincible Soviet Union hockey team in the 1980 Olympic games. The clip ends as U.S. fans, united in praise, wave their flags with pride and joy.	1.44
Subway Orchestra	On a subway ride, a flash mob emerges with a full orchestra performance, uniting a crowd of strangers in gratitude by an unexpected act of beauty and kindness.	2.00
Winnie Mandela	Inspirational movie trailer on South Africa's fight for freedom against the Apartheid featuring the story and words of lead activist, Winnie Mandela.	2.13
Hot Cross Buns (Control)	Tutorial on how to play "Hot Cross Buns" on the piano.	2.06

Crocodile	Footage of a crocodile stunt show that goes terribly wrong when a stuntman sticks his arm in the crocodile's mouth with the intent of pulling it out, and the crocodile comes down on the arm and performs a "crocodile death roll;" a trick used in the wild to rip off the limbs of prey.	1.42
Global Warming	An animated clip featuring a monkey who hangs himself, a polar bear who drowns himself and a kangaroo who jumps in front of a train to escape the reality of a future influenced by global warming.	1.05
911 Call	Transcribed audio recording of a 911 call juxtaposed against live footage of the twin tower buildings as they were burning down on 9/11. The call features a man pleading for help from the dispatcher, interrupted by a loud shout as he cries out to God and his building crumbles to the ground.	2.05
Auschwitz	Slideshow of photographs revealing the reality of the lives of those who were imprisoned, starved, and executed at Auschwitz.	2.45
Nip Tuck	Opening scene of an episode from *Niptuck*, featuring a woman undergoing plastic surgery fully conscious, but unable to move or speak aloud. Unaware, the surgeons continue to slice open her face as the voice in her mind cries out in pain, pleading for them to stop.	2.11
Suicide in C Sharp	Footage of an illusion act from the magic show, *Dirty Tricks.* Accompanied by violin, two men create the illusion of mutilating their arms with large knives, while behaving as if they are stroking violins with a bow.	1.48
911 News	Live news coverage from 9/11. As reporters discuss the aftermath of the first plane crash, the second plane flies across the screen, crashes into the South tower, and erupts into flames. The clip ends with a woman who calls in as an eyewitness and	1.32

concludes, in front of America, that what she just saw was not an accident, but a deliberate act of terrorism.

Table 2

Descriptive statistics

Variable	Mean	Variance			α
		Between Persons	Between Videos	Cell Level	
Chills sensations					
Goosebumps	.68	.08	.05	.14	.93
Tingling	.70	.07	.06	.15	.92
Coldness	.48	.05	.54	.14	.98
Shivers	.62	.06	.27	.15	.92
Circumplex affect					
Pleasant (0°)	.44	.00	1.36	.05	
Activated Pleasure (30°)	.40	.01	1.27	.07	
Pleasant Activation (60°)	.48	.05	.45	.14	
Activated (90°)	.48	.07	.18	.17	
Unpleasant Activation (120°)	.49	.04	.67	.14	
Activated Displeasure (150°)	.52	.02	.72	.10	
Unpleasant (180°)	.52	.01	1.22	.09	
Deactivated Displeasure (210°)	.45	.01	.98	.11	
Unpleasant Deactivation (240°)	.16	.02	.11	.10	
Deactivated (270°)	.42	.04	.38	.17	
Pleasant Deactivation (300°)	.37	.02	.63	.12	
Deactivated Pleasure (330°)	.36	.01	1.23	.08	

Note. α = Cronbach's alpha. Descriptive statistics reflect estimates after variables were dichotomized.

Table 3

Multilevel Model Predicting Circumplex Affect from Goosebumps, Tingling, Coldness, Shivers: Standardized coefficients

Circumplex Affect	Goosebumps	Tingling	Coldness	Shivers
Between Persons				
Pleasant (0°)	.61	.62	.54	.61
Activated Pleasure (30°)	.58	.62	.50	.46
Pleasant Activation (60°)	.47	.57	.43	.47
Activated (90°)	.58	.68	.50	.54
Unpleasant Activation (120°)	.64	.70	.46	.65
Activated Displeasure (150°)	.62	.67	.45	.60
Unpleasant (180°)	.36	.42	.20	.50
Deactivated Displeasure (210'	.39	.45	.16	.44
Unpleasant Deactivation (240'	.33	.41	.32	.36
Deactivated (270°)	.27	.30	.20	.30
Pleasant Deactivation (300°)	.22	.21	.25	.27
Deactivated Pleasure (330°)	.46	.44	.41	.52
Between Videos				
Pleasant (0°)	-.07	.66	-.96	-.93
Activated Pleasure (30°)	-.06	.70	-.96	-.94
Pleasant Activation (60°)	-.10	.56	-.93	-.74
Activated (90°)	.23	-.03	.17	.54
Unpleasant Activation (120°)	.12	-.57	.83	.94
Activated Displeasure (150°)	.07	-.59	.92	.94
Unpleasant (180°)	.19	-.61	.99	.92
Deactivated Displeasure (210'	.21	-.45	.95	.74
Unpleasant Deactivation (240'	-.20	-.46	.57	.12
Deactivated (270°)	-.05	.33	-.35	-.72
Pleasant Deactivation (300°)	-.12	.58	-.89	-.92
Deactivated Pleasure (330°)	-.08	.65	-.94	-.92

1) Cell Level

Pleasant (0°)	.01	.02	-.09	.01
Activated Pleasure (30°)	.06	.07	-.06	.01
Pleasant Activation (60°)	.04	.02	-.04	.02
Activated (90°)	.11	.09	.03	.14
Unpleasant Activation (120°)	.11	.10	.10	.14
Activated Displeasure (150°)	.12	.11	.16	.16
Unpleasant (180°)	.06	.02	.17	.08
Deactivated Displeasure (210'	.09	.07	.15	.07
Unpleasant Deactivation (240'	-.06	-.06	.02	-.01
Deactivated (270°)	-.05	-.06	.01	-.05
Pleasant Deactivation (300°)	-.05	-.06	-.07	-.10
Deactivated Pleasure (330°)	-.03	-.02	-.09	-.03

Table 4

Results of Cosine Wave Technique:
Fitting a cosine wave function to a series of correlations between the 12-Point Affect of Circumplex and four chills sensations (goosebumps, tingling, coldness shivers)

			Parameter Estimates from NLR					
			a	b	d	R^2	â (degrees)	r_{max}
2)	*Cell Level*							
		Goose	.03	-.08	1.07	.82	118.87	.12
		Tingle	.03	-.08	1.21	.73	110.90	.10
		Cold	.02	-.13	.18	.95	169.69	.15
		Shiver	.04	-.10	.91	.89	128.09	.14
Between 3)	*Videos*							
		Goose	.01	-.14	.64	.52	143.10	.15
		Tingle	.07	.74	.12	.94	6.59	.81
		Cold	-.05	-1.14	.10	.95	174.33	1.09
		Shiver	-.08	-1.11	.34	.94	160.52	1.03
Between Persons								
		Goose	.46	.17	-1.43	.68	81.70	.63
		Tingle	.51	-.19	1.55	.78	91.19	.69
		Cold	.37	.16	-.95	.74	54.49	.53
		Shiver	.48	-.12	1.49	.55	94.57	.60

Note. Cosine Wave Function: Y = a+b*cos(X+d); a, b, d are empirical estimates in NLR; X = pattern of correlations between external variable (e.g., goosebumps) and 12 circumplex affect variables (input = Table 3). When b > 0, â = – d; When b < 0, â = 3.14 – d; 3. rmax = a + b * cos(â + d), where the empirical estimates of a, b, and d, and â are inserted in the equation. R^2 = variance explained by the cosine curve; â = circumplex angle in degrees; r_{max} = magnitude of the relation with the circumplex angle (â). For detailed instructions to the cosine wave technique see Appendix A (M. Yik, personal correspondence, April 2, 2018).

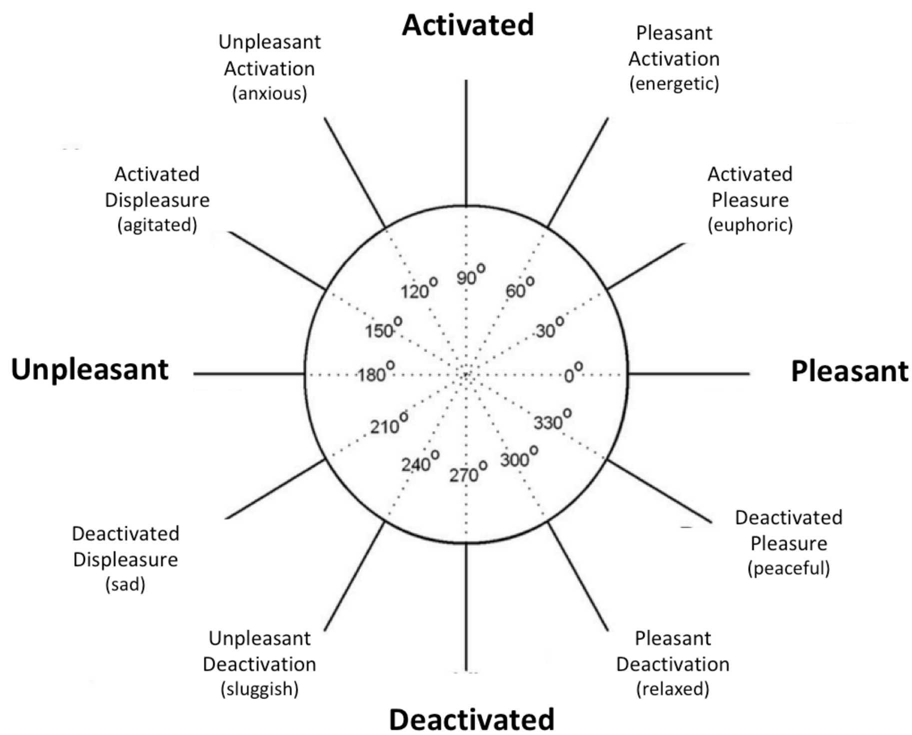

Figure 1. The 12-Point Circumplex Model of Core Affect (12-PAC; Yik et al., 2011).

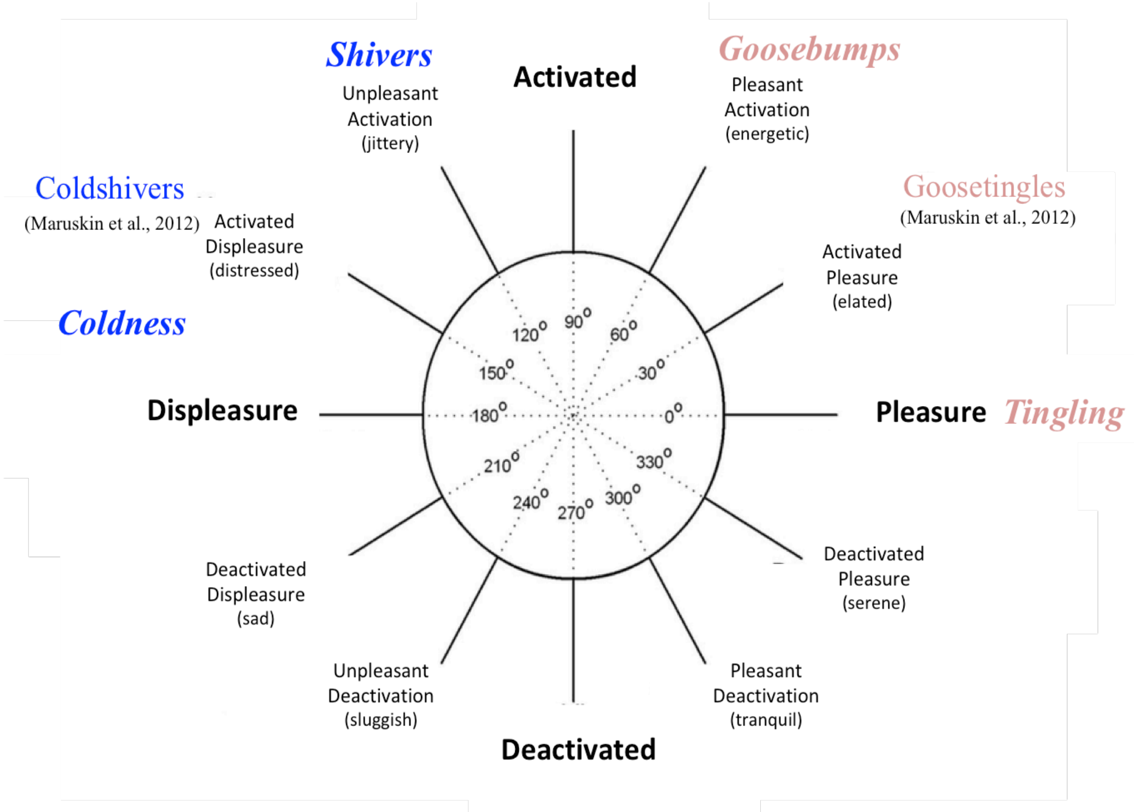

Figure 2. The 12-Point Circumplex Model of Core Affect (Yik et al., 2011) indicating where goosetingles and coldshivers are predicted to fall based on past research (Maruskin et al., 2012), and where goosebumps, tingling, coldness, and shivering are hypothesized to fall based on my review of the literature.

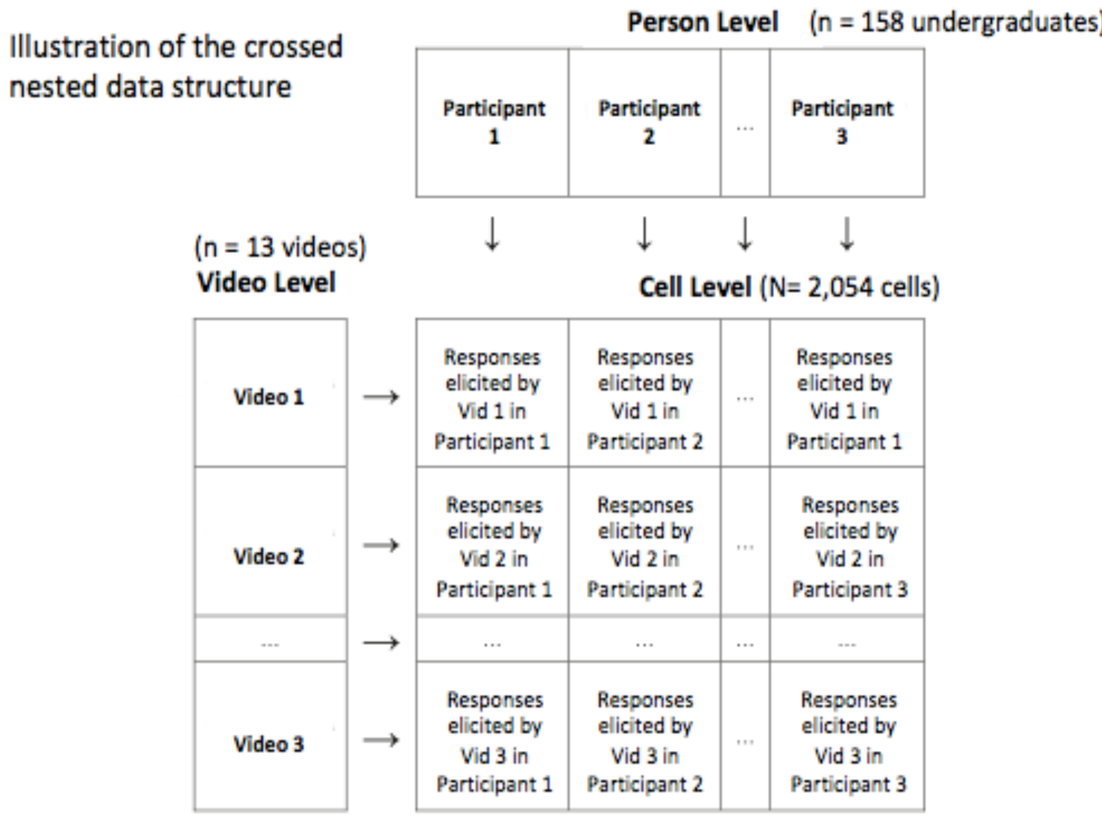

Figure 3. Illustration of the data structure showing variance decomposed into three orthogonal levels of analysis: two upper levels of analysis, Between Videos Level and Between Persons Level, and one lower level of analysis, at the Cell Level (Raudenbush & Bryk, 2002).

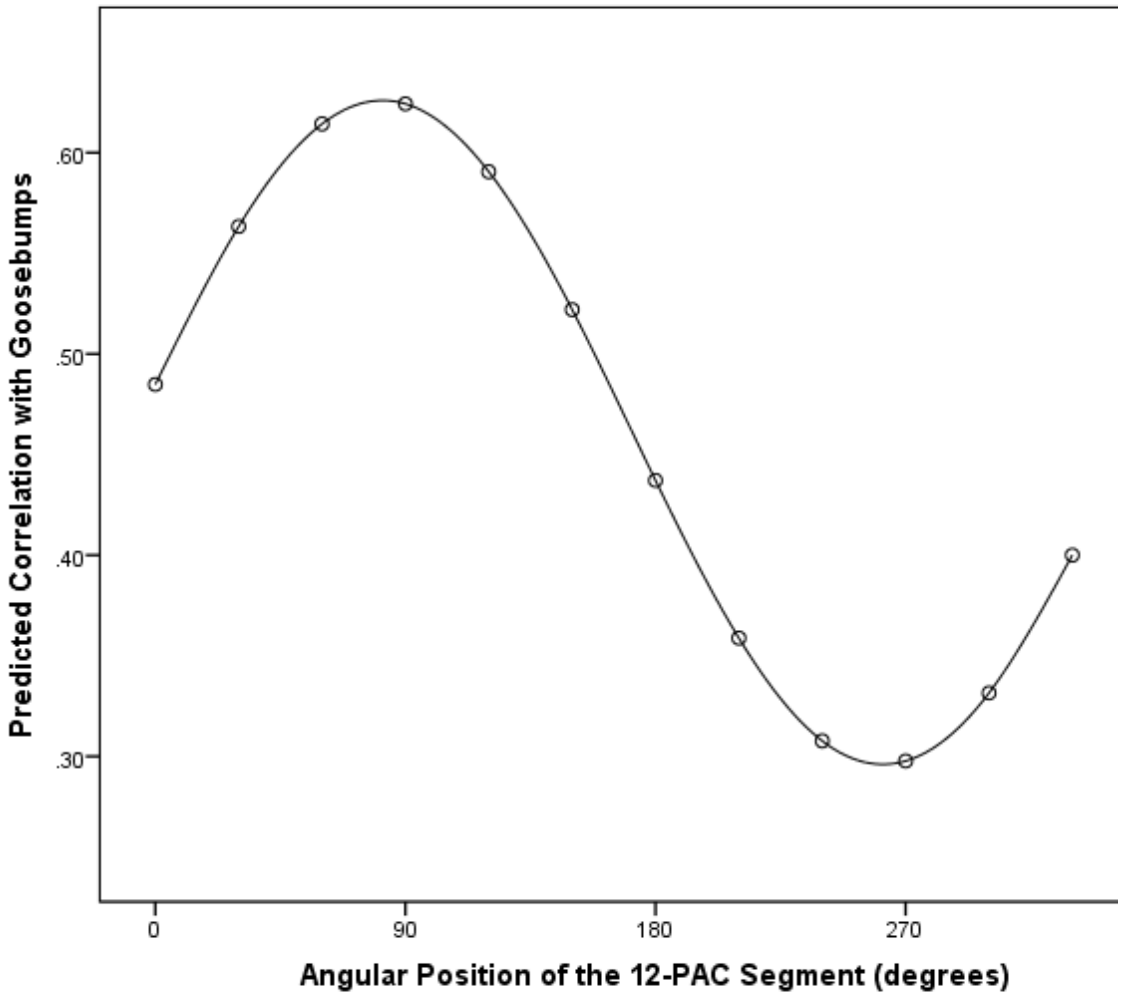

Figure 4. Between Persons level correlation of Goosebumps with each segment of the 12-PAC as a function of the angle within the circumplex for that; R^2 = .68. Those who reported feeling goosebumps also tended to report a specific state of core affect best characterized by the peak of the curve at 81.7º in the 12-PAC (â = 81.7). The magnitude of the association between goosebumps and the vector at 81.7º is estimated at r_{max} =.63.

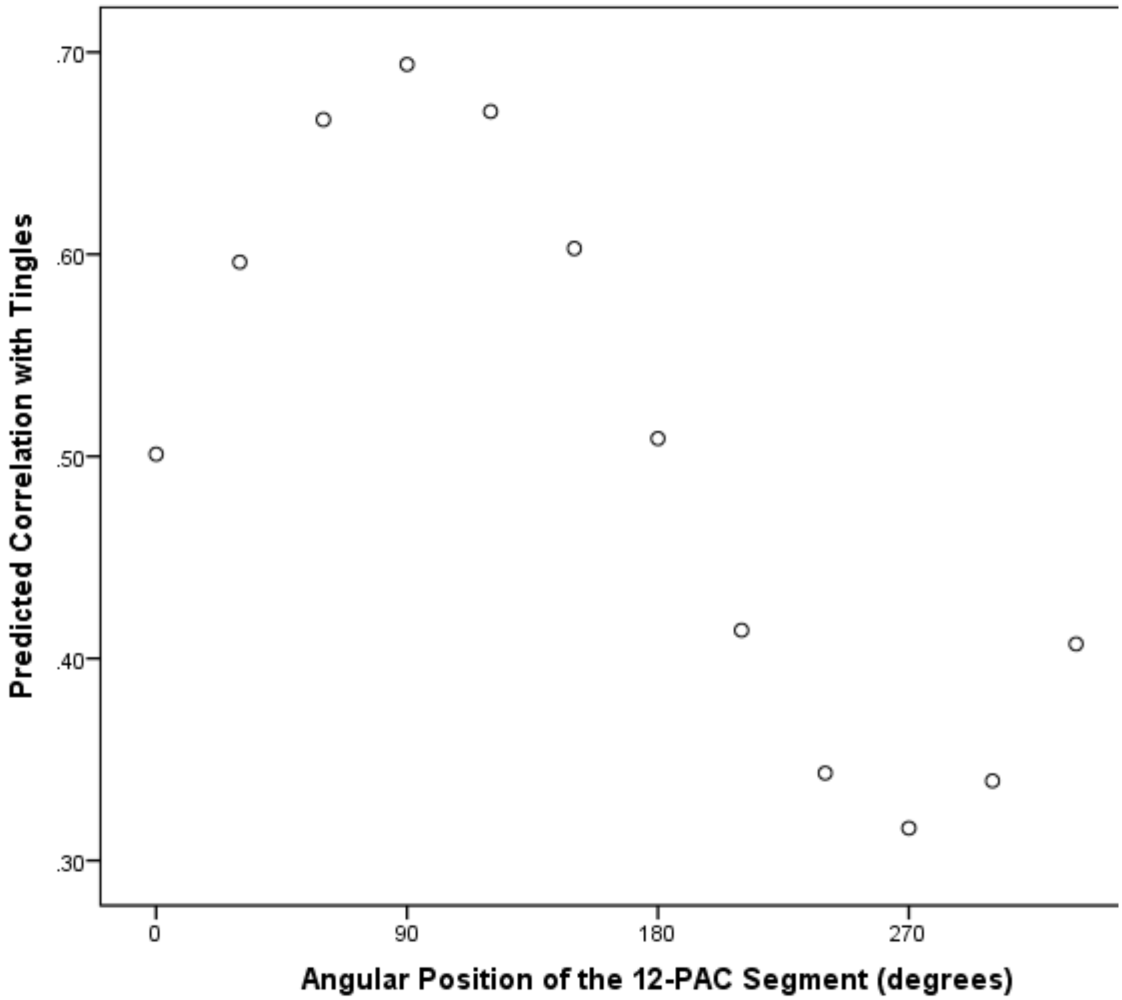

Figure 5. Between Persons level correlation of Tingles with each segment of the 12-PAC as a function of the angle within the circumplex for that. Those who reported feeling tingles also tended to report a specific state of core affect best characterized by the peak of the curve at 91.19º in the 12-PAC (â = 91.19). The magnitude of the association between tingling and the vector at 91.19º is estimated at r_{max} =.69.

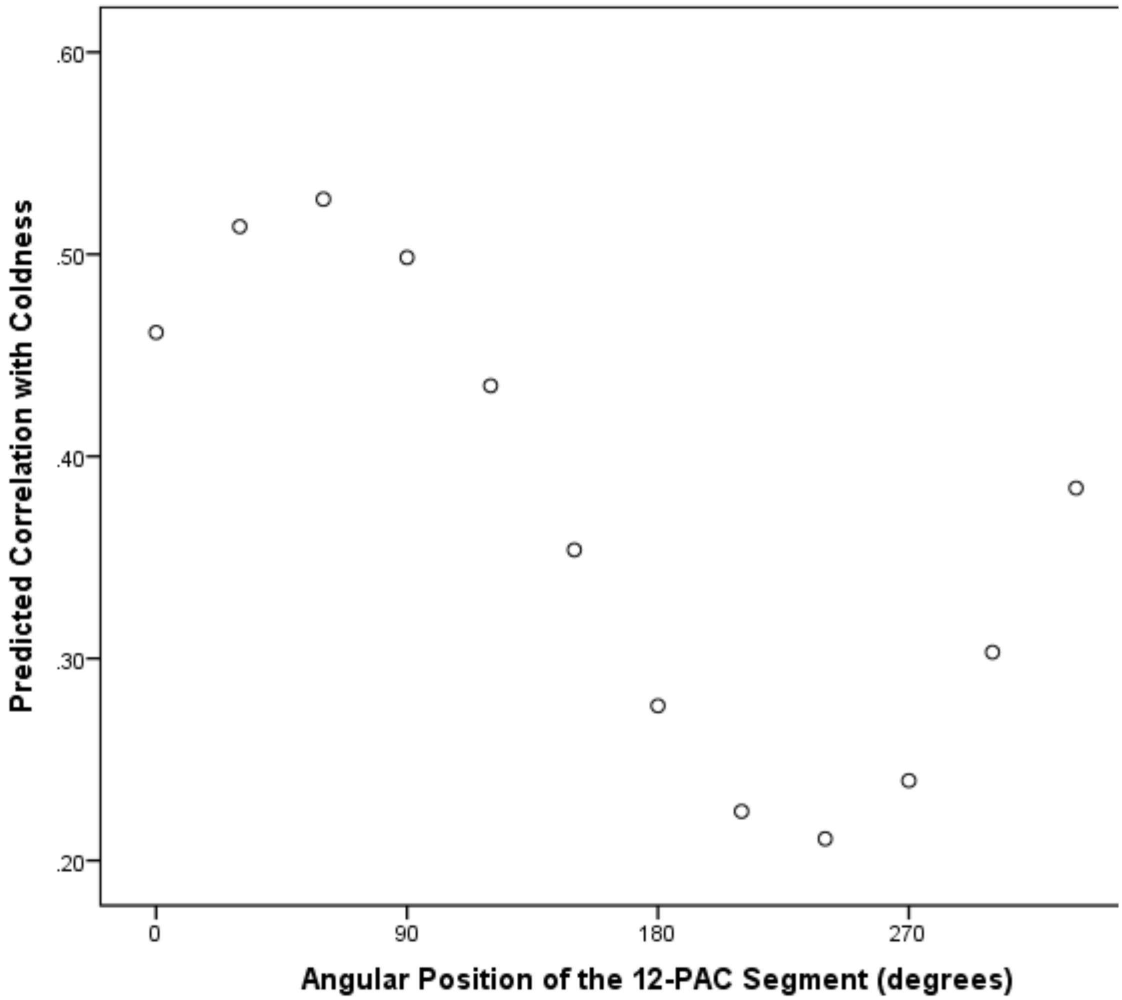

Figure 6. Between Persons level correlation of Coldness with each segment of the 12-PAC as a function of the angle within the circumplex for that. Those who reported feeling coldness also tended to report a specific state of core affect best characterized by the peak of the curve at 54.49º in the 12-PAC (â = 54.49). The magnitude of the association between coldness and the vector at 54.49º is estimated at r_{max} =.53.

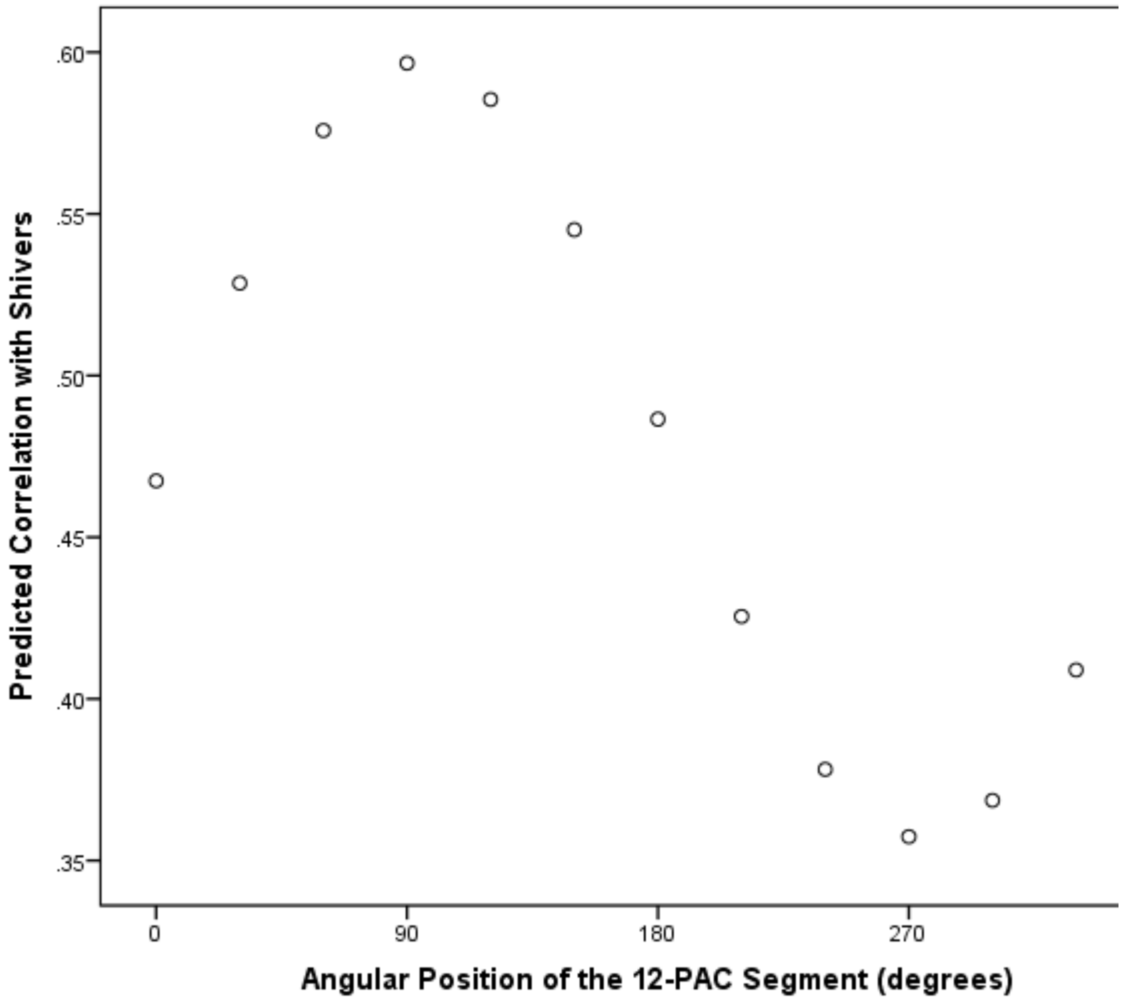

Figure 7. Between Persons level correlation of Shivers with each segment of the 12-PAC as a function of the angle within the circumplex for that. Those who reported feeling shivers also tended to report a specific state of core affect best characterized by the peak of the curve at 54.49º in the 12-PAC (â = 94.57). The magnitude of the association between shivers and the vector at 94.57 is estimated at r_{max} =.60.

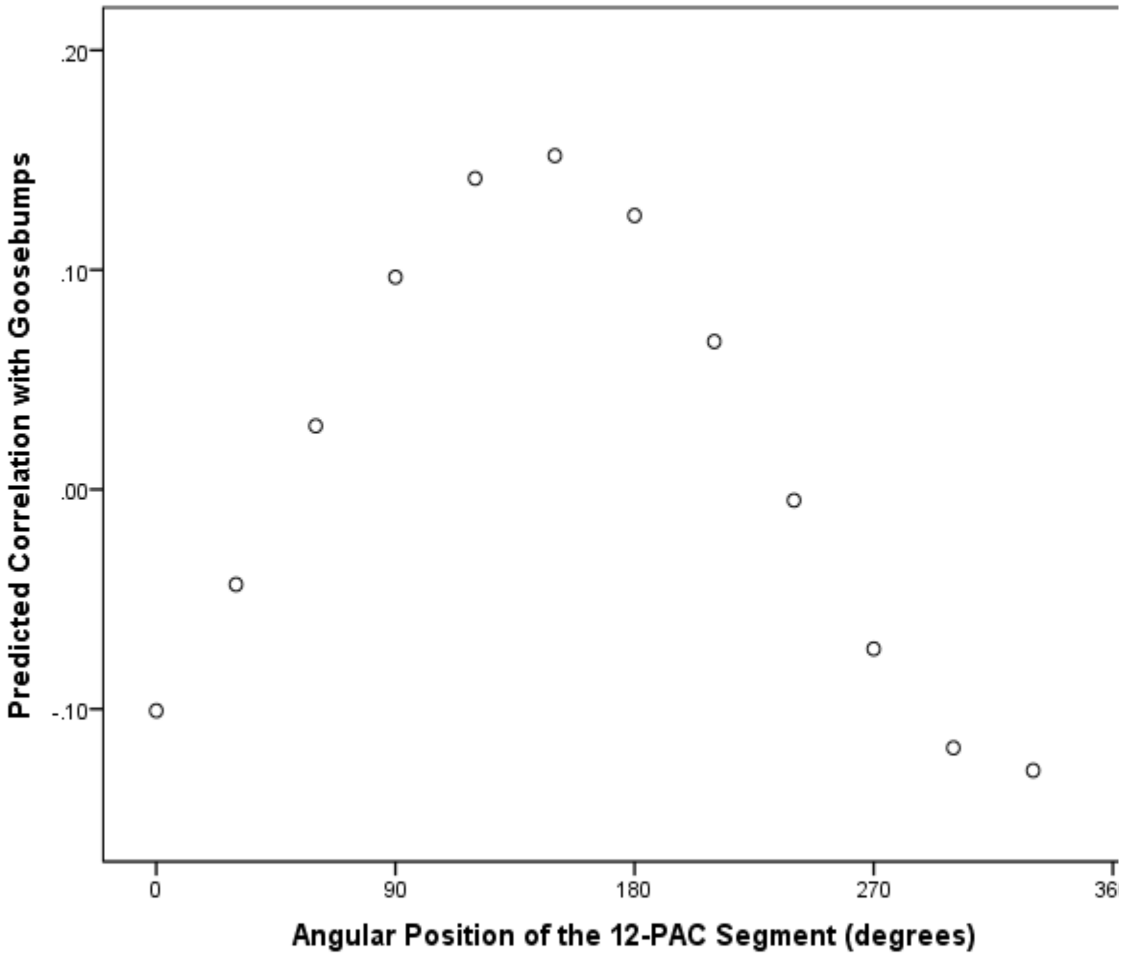

Figure 8. Between Videos level correlation of Goosebumps with each segment of the 12-PAC as a function of the angle within the circumplex for that. Videos that elicited goosebumps also tended to elicit a specific state of core affect best characterized by the peak of the curve at 143.10º in the 12-PAC (â = 143.10). The magnitude of the association between goosebumps and the vector at 143.10 is estimated at r_{max} =.15.

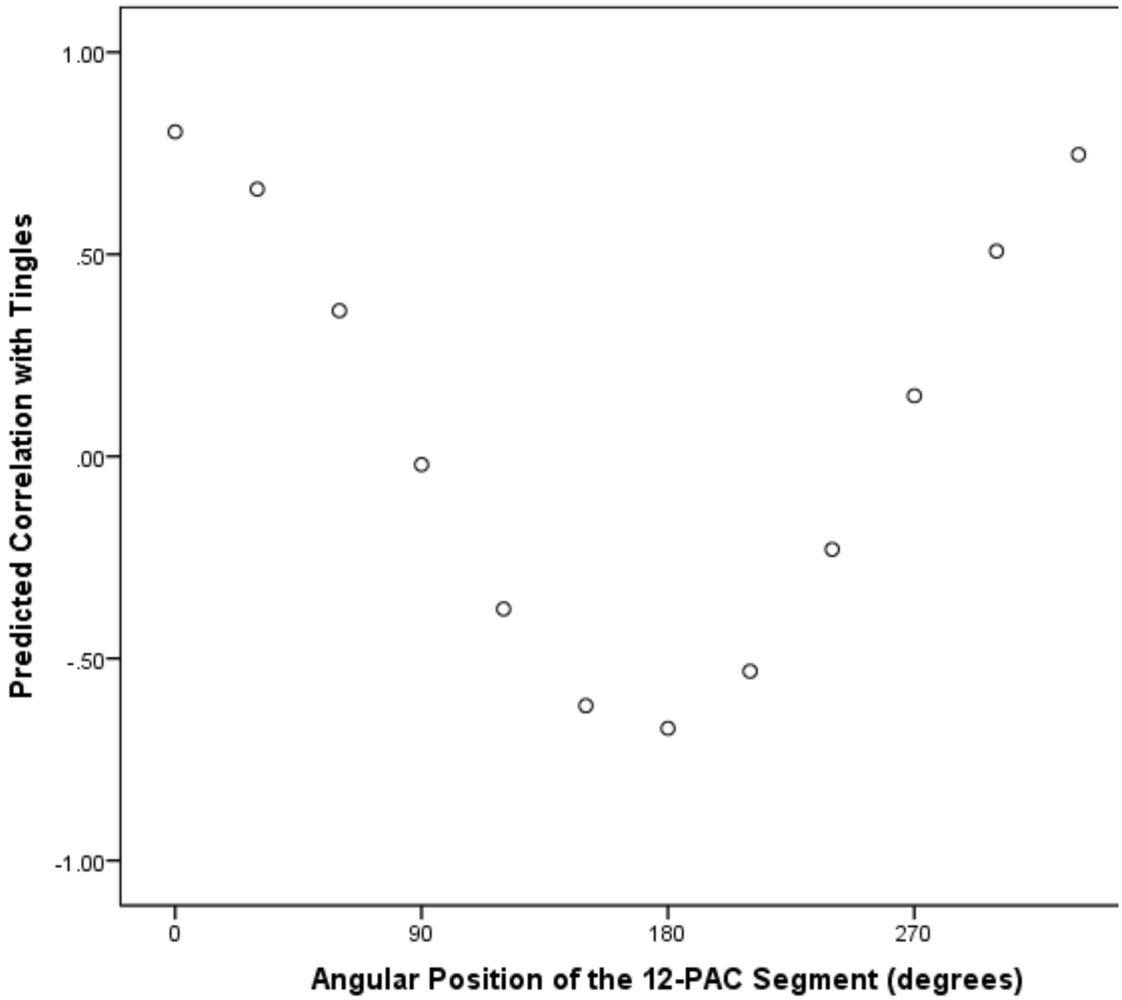

Figure 9. Between Videos level correlation of Tingles with each segment of the 12-PAC as a function of the angle within the circumplex for that. Videos that elicited tingling also tended to elicit a specific state of core affect best characterized by the peak of the curve at 6.59º in the 12-PAC (â = 6.59). The magnitude of the association between tingling and the vector at 6.59 is estimated at r_{max} = .81.

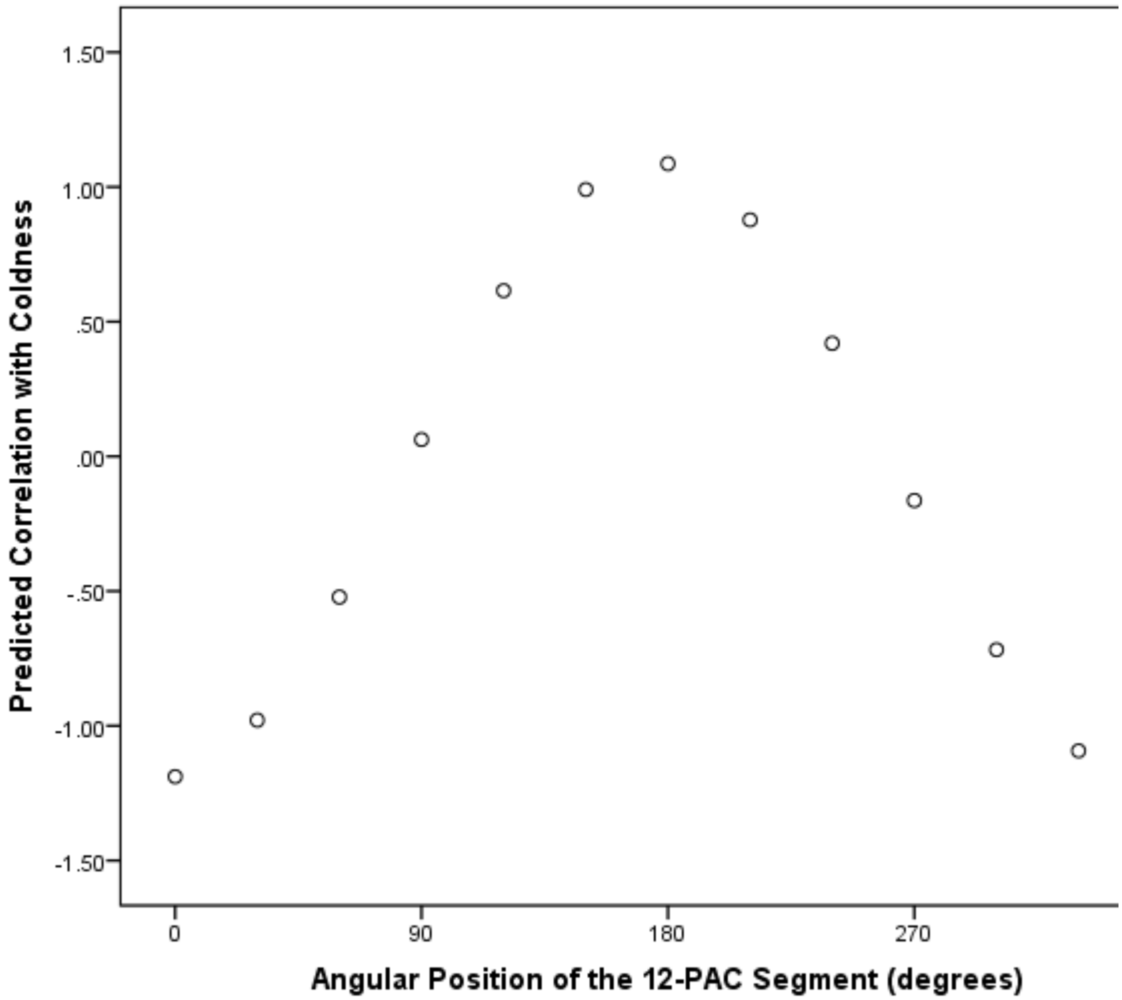

Figure 10. Between Videos level correlation of Coldness with each segment of the 12-PAC as a function of the angle within the circumplex for that. Videos that elicited coldness also tended to elicit a specific state of core affect best characterized by the peak of the curve at 174.33º in the 12-PAC (â = 174.33). The magnitude of the association between coldness and the vector at 174.33 is estimated at r_{max} =.1.09

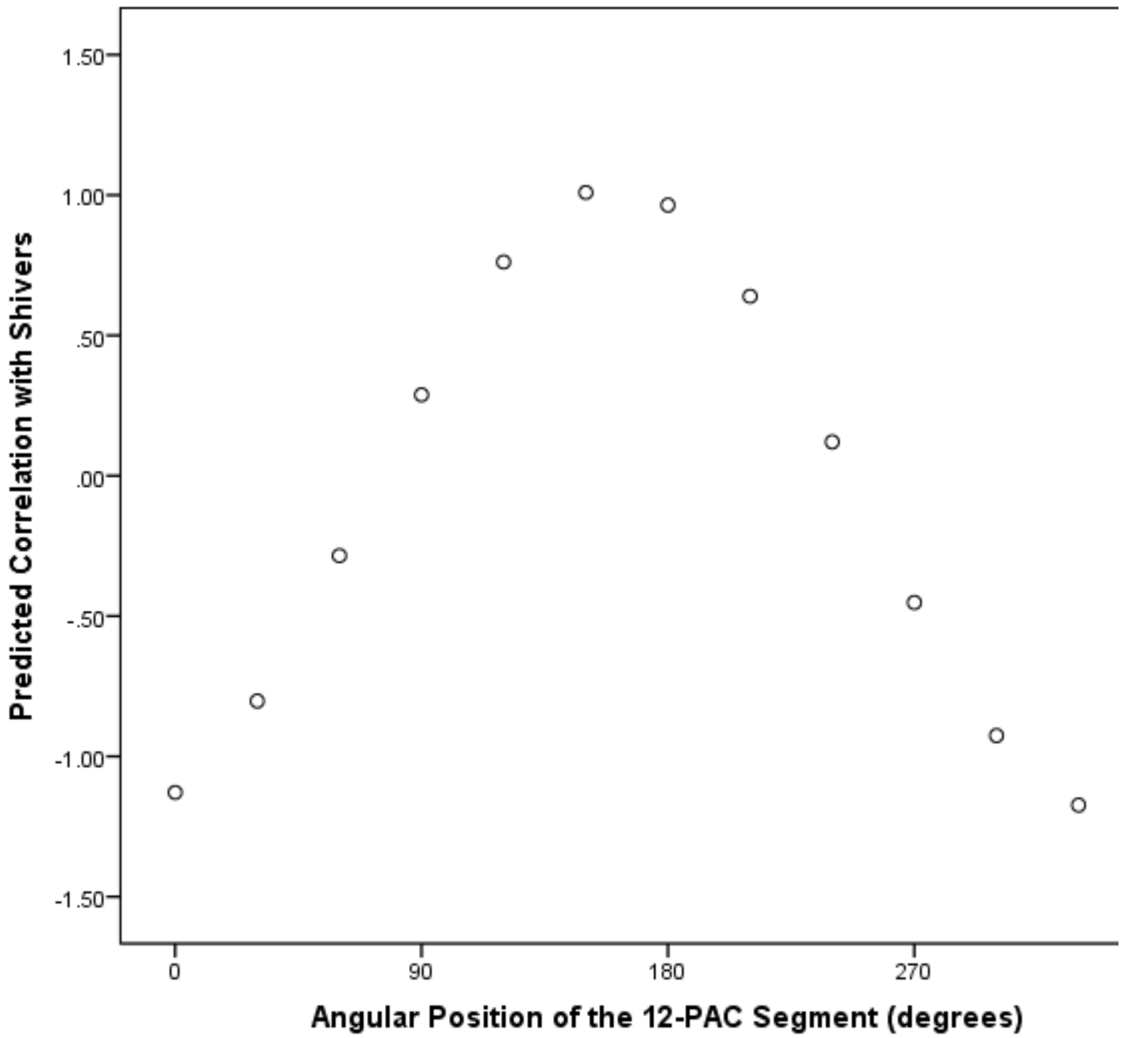

Figure 11. Between Videos level correlation of Shivers with each segment of the 12-PAC as a function of the angle within the circumplex for that. Videos that elicited shivering also tended to elicit a specific state of core affect best characterized by the peak of the curve at 160.52º in the 12-PAC (â = 160.52º). The magnitude of the association between shivers and the vector at 160.52º is estimated at r_{max} =.1.03.

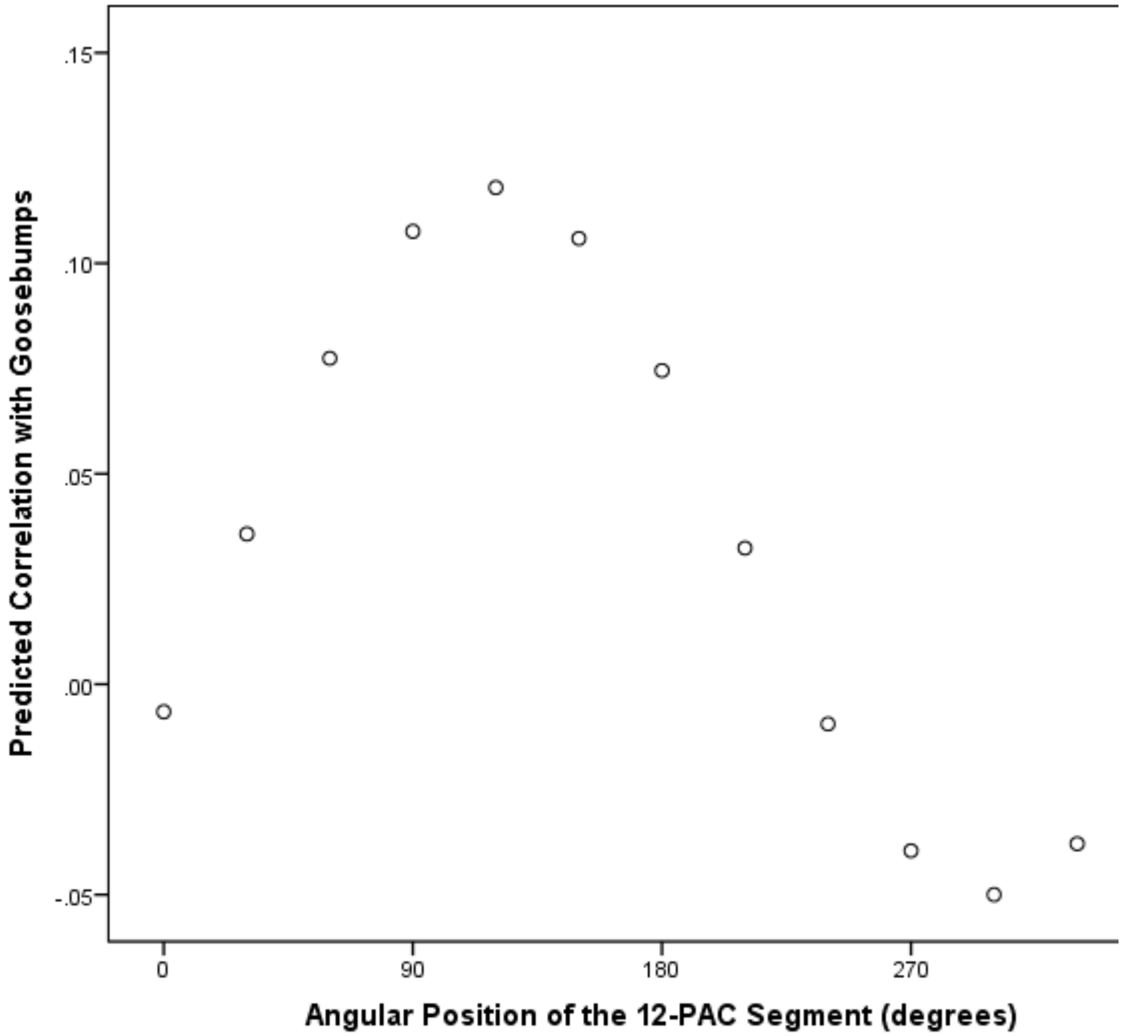

Figure 12. Cell level correlation of Goosebumps with each segment of the 12-PAC as a function of the angle within the circumplex for that. The unique pairing of certain individuals watching particular videos that sporadically elicited goosebumps also tended to sporadically elicit a specific state of core affect best characterized by the peak of the curve at 118.87º in the 12-PAC (â = 118.87º). The magnitude of the association between goosebumps and the vector at 118.87º is estimated at r_{max} =.12.

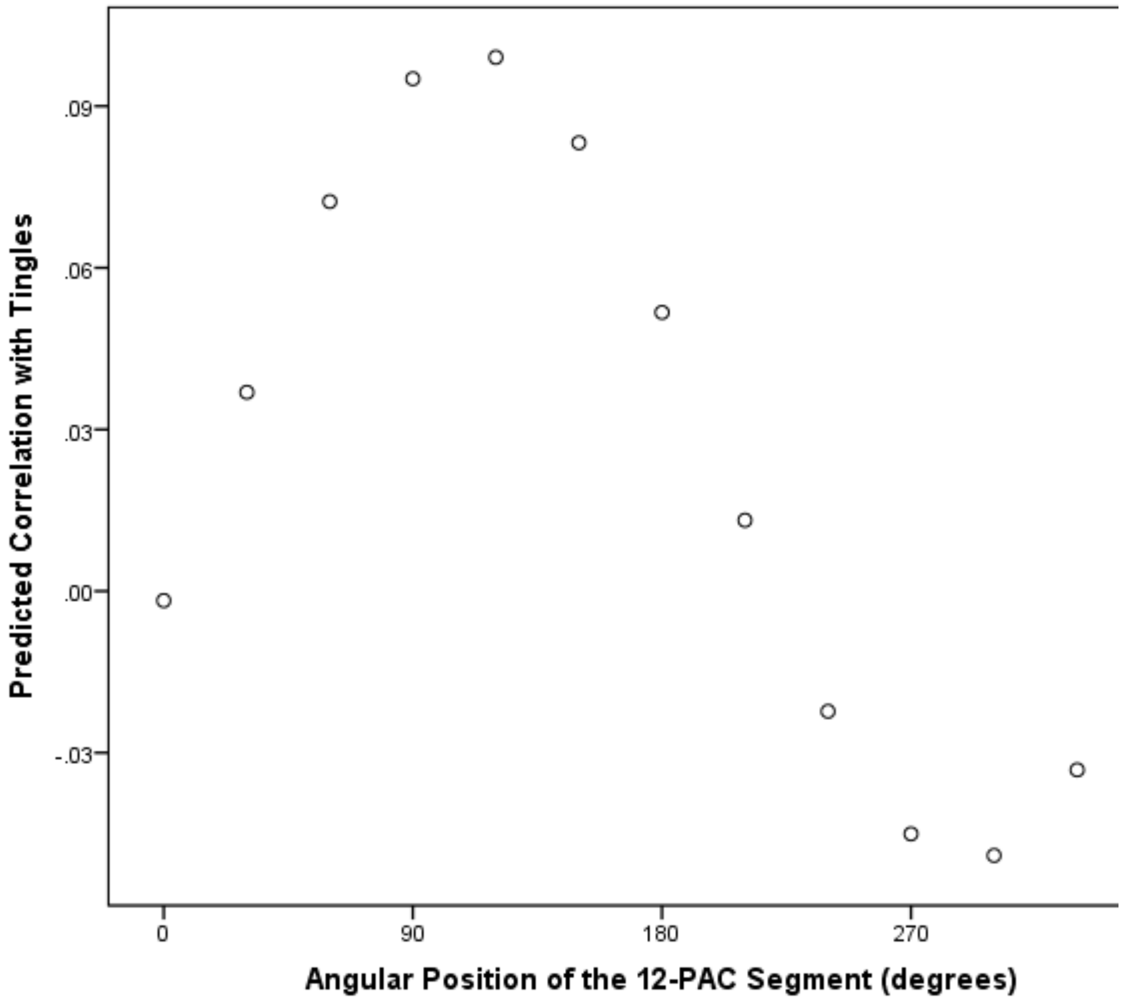

Figure 13. Cell level correlation of Tingles with each segment of the 12-PAC as a function of the angle within the circumplex for that. The unique pairing of certain individuals watching particular videos that sporadically elicited goosebumps also tended to sporadically elicit a specific state of core affect best characterized by the peak of the curve at 110.90º in the 12-PAC (â = 110.90º). The magnitude of the association between tingling and the vector at 110.90º is estimated at r_{max} =.10.

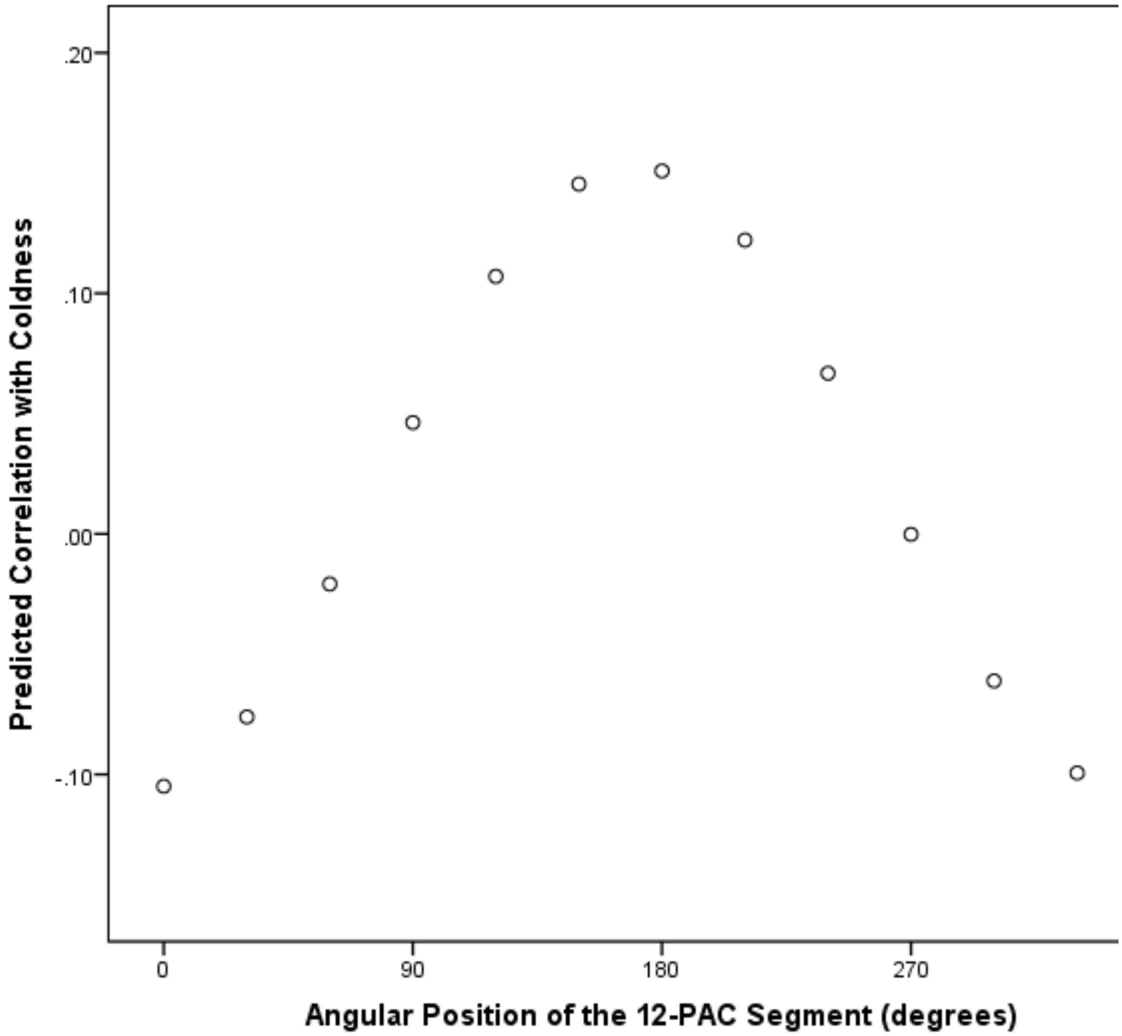

Figure 14. Cell level correlation of Coldness with each segment of the 12-PAC as a function of the angle within the circumplex. The unique pairing of certain individuals watching particular videos that sporadically elicited goosebumps also tended to sporadically elicit a specific state of core affect best characterized by the peak of the curve at 169.69º in the 12-PAC (â = 169.69º). The magnitude of the association between coldness and the vector at 169.69º is estimated at r_{max} =.15.

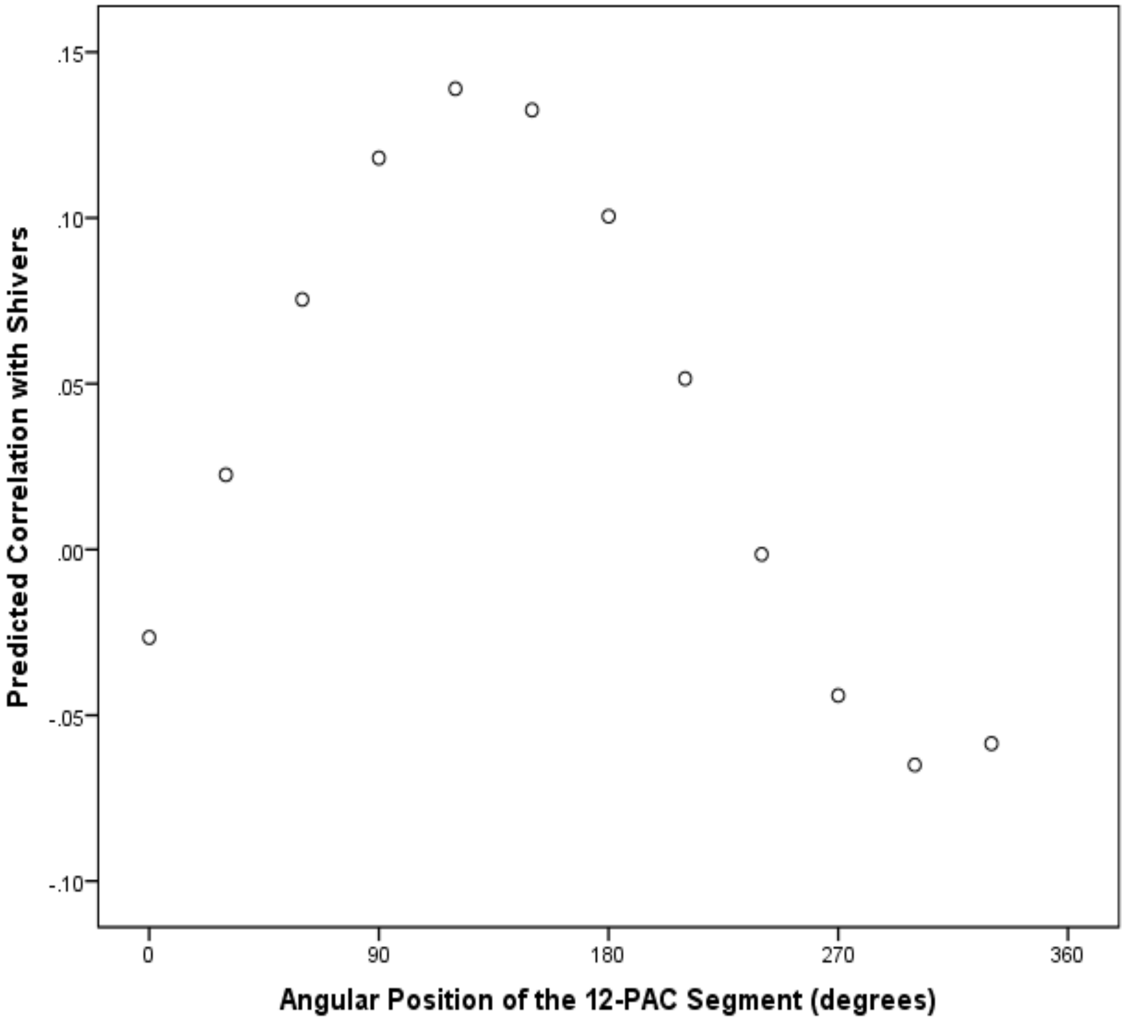

Figure 15. Cell level correlation of Shivering with each segment of the 12-PAC as a function of the angle within the circumplex. The unique pairing of certain individuals watching particular videos that sporadically elicited goosebumps also tended to sporadically elicit a specific state of core affect best characterized by the peak of the curve at 128.09º in the 12-PAC (â = 128.09º). The magnitude of the association between shivers and the vector at 128.09º is estimated at r_{max} =.14

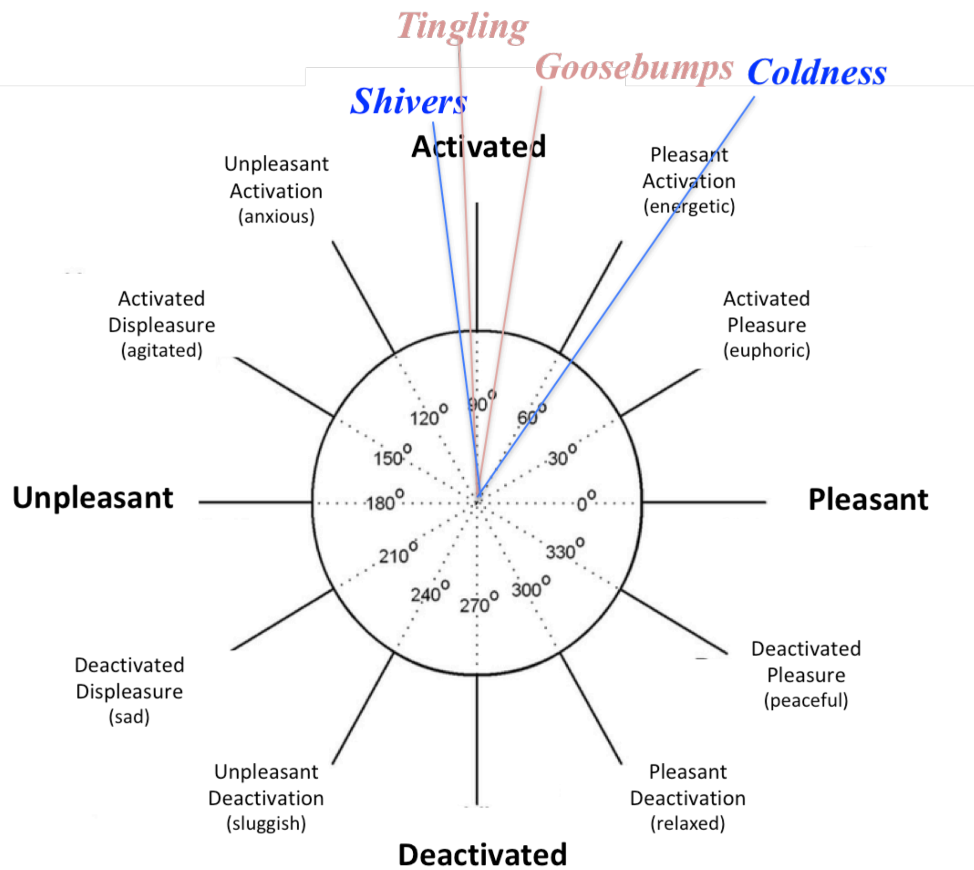

Figure 16. Between Person Level Results: Estimated placement of Goosebumps, Tingling, Coldness, Tingling within the 12-Point Circumplex Model of Core Affect (Yik et al., 2011).

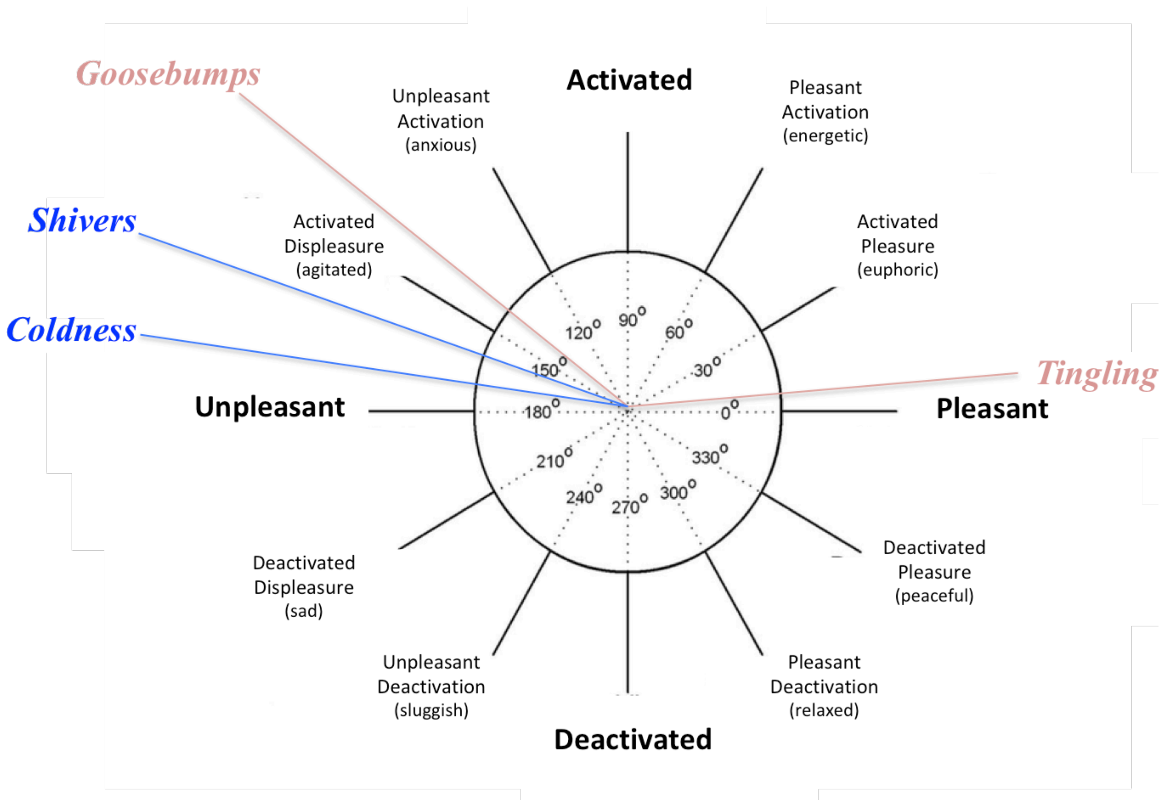

Figure 17. Between Video Level Results: Estimated placement of Goosebumps, Tingling, Coldness, Tingling within the 12-Point Circumplex Model of Core Affect (Yik et al., 2011).

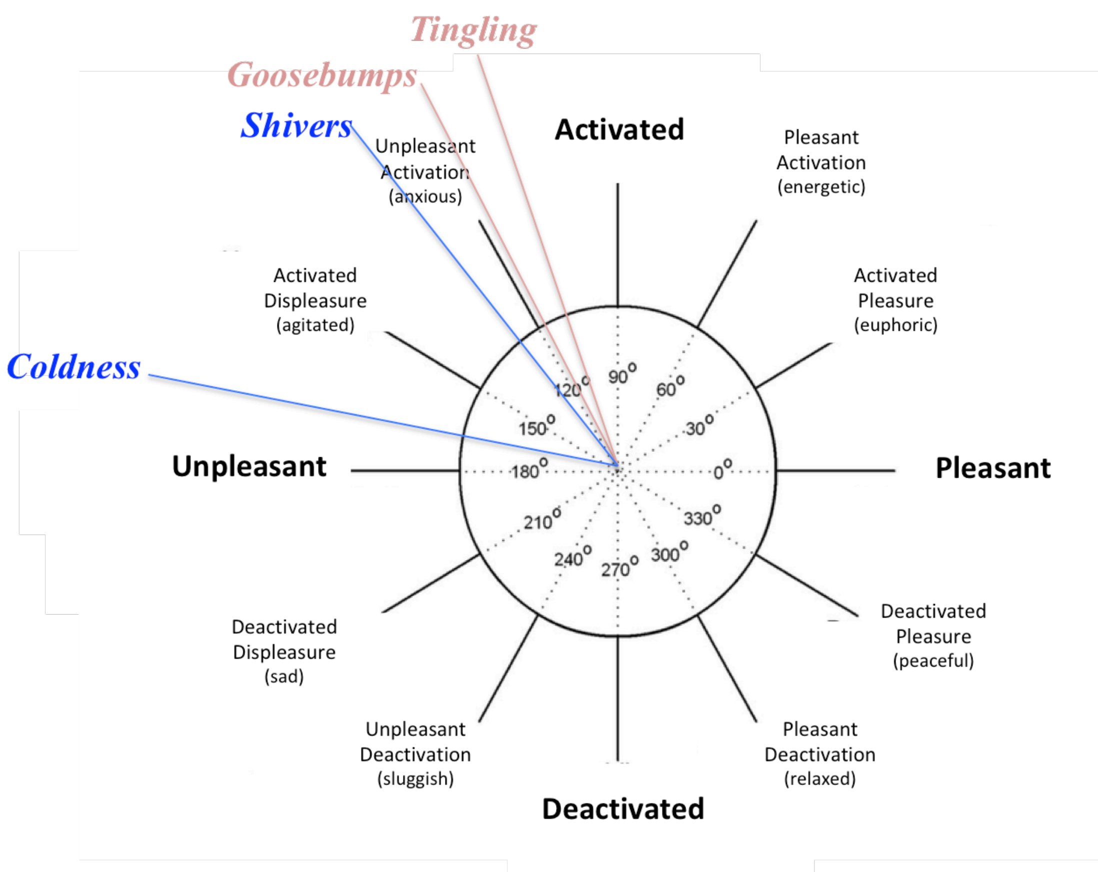

Figure 18. Cell Level Results: Estimated placement of Goosebumps, Tingling, Coldness, Tingling within the 12-Point Circumplex Model of Core Affect (Yik et al., 2011).

Appendix A.

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Placing External Variables within a Circumplex Model of Affect: The Cosine Wave Technique

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The circumplex provides a simple but powerful prediction about the pattern of correlations between the variables within a circumplex model and any external variable (variable not used to define the circumplex). The principle is that any external variable that correlates with one variable within a circumplex model will correlate with the remaining variables in a systematic way. The magnitude of that correlation will rise and fall in a cosine wave pattern as one moves around the circumference of the circumplex (e.g., Stern, 1970; Wiggins, 1979). It is the finding of a cosine wave, rather than the statistical significance of any individual correlation, that indicates the presence of a relation between an external variable and the circumplex. In this technical note, we describe a step-by-step procedure to place an external variable within Yik, Russell, and Steiger's (2011; see also Yik, 2009) 12-Point Affect Circumplex, as shown in Figure 1. This method estimates the precise location of an external variable within the circumplex and its magnitude of relation with the affect.

The Method

Our method relies on fitting a cosine wave function to a series of correlations between the circumplex (affect) variables and an external variable (e.g., mood, trait). To chart the relation between an external variable and the 12-PAC segments, we rely on the general form of the cosine function:

$$Y = a + b*\cos(X + d)$$

where Y is the correlation between each segment and the external variable; X is the angle for the segment within the circumplex model; a, b, and d are constants to be estimated in a nonlinear estimation procedure. a adjusts the values of Y to fit the cosine function; b indicates the amplitude of the cosine wave; d indicates the start value of X when it does not start at 0. If a = 0, b = 1, and d = 0, the general form of the cosine function reduces to the commonly seen Y = cos(X).

This method produces for each analysis three outcomes: â (a-hat) is the estimated angle of the external variable within the circumplex model; rmax (r-max) is the maximum correlation between the external variable and a vector within the 12-PAC at â; and VAF (variance accounted for) is the amount of variance explained by the cosine curve.

In the following, we used the data reported in Study 3 of Yik, Russell, and Steiger (2011) to illustrate this empirical method placing two external variables within the 12-PAC space.

Placing a Mood Scale within the 12-PAC Space

To chart the relationship betweeen the mood scale of Fear (Watson & Clark, 1994) and the 12-PAC segments, we fit a cosine wave function to the series of correlations between the 12 affect segments and the Fear scale.

The results are illustrated in Figure 2 for the mood scale of Fear. Each of the 12-PAC segments is represented on the abscissa by its angle derived from CIRCUM (Browne, 1992). The ordinate is that segment's correlation with Fear. As predicted, the pattern of correlations approximated a cosine curve. The fit of the pattern of correlations to a cosine function is indicated by the variance accounted for (VAF) in the 12 data points by a cosine curve, which, in this particular case, was 99%. Figure 2 shows that those who reported feeling fearful at the moment of the test were also highly likely to report a specific state of Core Affect (activated displeasure) best characterized by the peak of the fitted curve at 149° _in the 12-PAC, an angle we term â (a-hat). The magnitude of the relation is estimated as the correlation (in this case estimated as .80) with a vector at exactly 149°, a correlation we term rmax (r-max). Fear does not overlap precisely with any one of the 12-PAC segments actually measured. Thus, .80 is interpreted as an estimate of the correlation between the mood scale of Fear with a hypothetical variable located at 149° _in the 12-PAC space. More generally, the fitted curve in Figure 2 shows the predicted correlation of Fear with every point along the circumplex.

Figure 2. The correlation of the mood scale of Fear (ordinate) as a function of the angle within the 12-PAC. The value for the affect variable at 0° _is repeated at 360° _to show the complete cosine cycle.

Merely by chance, data can fit a cosine curve with a VAF greater than zero. To quantify this possibility, a Monte Carlo study was conducted and reported in Yik, Russell, and Steiger (2011, footnote 6). With 10,000 trials, the distribution of the values of VAF when association between angle and correlation was random was estimated. The mean VAF was 18.1% (SD = 14.3%). Values of VAF equal to or greater than 45.5% were obtained in 5% of cases, values equal to or greater than 57.6% in 1% of cases. These benchmarks serve well to determine which VAF values indicate a reliable cosine pattern. By this standard, the value of VAF for the mood scale of Fear was significant at .01 level implying that the pattern of correlations yielded a reliable cosine pattern.

Placing a Trait Scale within the 12-PAC Space

Next we sought to chart the relation between a trait scale of Behaviroal Inhibition Scale (BIS; Carver & White, 1994) and the 12-PAC segments. The results are illustrated in Figure 3. The VAF was 99% showing that the 12 correlations of BIS with each of the 12-PAC segments formed a cosine curve.

Figure 3. The correlation of the trait scale of BIS (ordinate) as a function of the angle within the 12-PAC. The value for the affect variable at 0° _is repeated at 360° _to show the complete cosine cycle.

Figure 3 contrasts with Figure 2 in understandable ways. Although both analyses showed reliable fit to a cosine wave, the peaks of the two curves differed somewhat and their magnitude of relation differed a lot. Those individuals who describe themselves as behaviorally inhibited had a moderate tendency to report a specific state of Core Affect (displeasure with slightly elevated arousal), best characterized by the peak of the fitted curve at 175° _in the 12-PAC space. The magnitude of the relation is more modest (rmax = .35) than it had been for Fear. The contrast between Figure 2 and Figure 3 speaks to the debate about the distinction between states and traits (Allen & Potkay, 1981; Zuckerman, 1983). Scales of mood state, such as Fear, showed much higher correlations with the 12-PAC than did personality scales, thus supporting the distinction between states and traits.

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