Acta Psychologica 148 (2014) 136–147

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Perceptual symbols of creativity: Coldness elicits referential, warmth elicits relational creativity☆,☆☆

Hans IJzerman [a,*], Angela K.-y. Leung [b], Lay See Ong [b]

[a] Tilburg University, Department of Social Psychology, School of Social & Behavioral Sciences, Warandelaan 2, Prisma Building, Room P64, PO Box 90153, 5000 LE Tilburg, The Netherlands
[b] Singapore Management University, School of Social Sciences, 90 Stamford Road, Level 4, Singapore 178903, Singapore

ARTICLE INFO

Article history:
Received 19 March 2013
Received in revised form 3 January 2014
Accepted 18 January 2014
Available online xxxx

PsycINFO classification:
3000
2820
3040

Keywords:
Embodied Grounding
Warmth
Social Relations
Processing Styles
Creativity

ABSTRACT

Research in the cognitive and social psychological science has revealed the pervading relation between body and mind. Physical warmth leads people to perceive others as psychological closer to them and to be more generous towards others. More recently, physical warmth has also been implicated in the processing of information, specifically through perceiving relationships (via physical warmth) and contrasting from others (via coldness). In addition, social psychological work has linked social cues (such as mimicry and power cues) to creative performance. The present work integrates these two literatures, by providing an embodied model of creative performance through relational (warm = relational) and referential (cold = distant) processing. The authors predict and find that warm cues lead to greater creativity when 1) creating drawings, 2) categorizing objects, and 3) coming up with gifts for others. In contrast, cold cues lead to greater creativity, when 1) breaking set in a metaphor recognition task, 2) coming up with new pasta names, and 3) being abstract in coming up with gifts. Effects are found across different populations and age groups. The authors report implications for theory and discuss limitations of the present work.

1. Introduction

For painters, scientists, and business people alike, the blessed possession of creativity delivers fame and fortune, pushing creative performance to be the pinnacle of human culture. Given creativity's centrality in human thought and activity, creativity researchers have amassed empirical knowledge on the how-to by discerning the dispositional, cognitive, motivational, and affective determinants underlying mundane creative performance (e.g., Amabile, 1996; Csikszentmihalyi, 1996; Sawyer, 2006; Simonton, 2000, 2003). The current research seeks to advance existing creative cognition research by utilizing recent insights from *grounded cognition* to reveal how even the simplest thermal cues can sometimes lead people to be more and sometimes to be less creative.

To gain insights on how thermal cues can alter creative performance, first we draw on divergent literatures supporting the notion that interpersonal cues inspire and shape creative thought. As the literature has revealed, in some cases people seek to be creative by finding a common ground with others (such as in thinking of a good gift for a loved one; e.g., Kray, Galinsky, & Wong, 2006), whereas in other cases, people seek to be creative by stepping back and finding a novel solution to a specific problem (e.g., Smith & Blankenship, 1991). Second, in contrast to the assumptions posed by propositional systems that underlie much existing creativity research to represent thought as amodal (Barsalou & Prinz, 1997), we draw from an emerging *grounded* perspective of interpersonal relations that link thermal cues to interpersonal relations (IJzerman & Koole, 2011; IJzerman & Semin, 2009, 2010; Steinmetz & Mussweiler, 2011; Williams & Bargh, 2008; Zhong & Leonardelli, 2008) and apply this to creative cognition. We will thereafter propose that, (a) experiences of physical warmth trigger a focus on relationships and induce people to forge connections (relational creativity), whereas (b) experiences of physical coldness trigger people to break set (referential creativity; for a similar model from language, see IJzerman, Regenberg, Saddlemyer, & Koole, 2013).

We utilized one of the most basic cues for interpersonal contact – physical warmth versus coldness – to activate a psychologically connected versus distant experience and examined its impact on different tasks implicated in creative cognition. Notably, we do not suggest that our effects encompass *all* of creative cognition (e.g., the creation

☆☆ Authors' Notes: Data and materials of the paper will be uploaded to Tilburg Dataverse upon acceptance of the paper. IJzerman is responsible for collecting and analyzing the data for Studies 1, 3, and 4; Leung is responsible for collecting and analyzing the data for Study 2. IJzerman, Leung, and Ong were all responsible for writing the paper.

* Corresponding author. Tel.: +31 13 466 8169.
E-mail address: h.ijzerman@uvt.nl (H. IJzerman).

0001-6918/$ – see front matter © 2014 The Authors. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.actpsy.2014.01.013

of new and original ideas), but that the basic cue of physical warmth/coldness can elicit more or less shared ground with others which is pertinent to relational creativity and referential creativity, respectively. Employing a triangulation of methodologies, we studied our effects through three different manipulations of temperature, across different age groups, and in two distinct cultural samples. Together, this package explicates two major modes of creative cognition, drawing from the mind–body nexus to reveal how relational creativity is "warm" and referential creativity is "cold" (cf. Taft, 1971).

2. The interpersonal nature of creative performance

Creativity has often been proposed as the process of generating something both novel and useful (Amabile, 1996). An abundant literature has documented numerous personality factors that can enhance creative performance: Creative people tend to be more open to new experiences, resistant to norms, risk seeking, and intrinsically motivated (see Simonton, 2003). Likewise, many social-contextual factors have found to play a vital role in stimulating creative thought. Adopting a functional perspective, the evolutionary role of mundane creativity is believed to be critical in the interpersonal sphere; indeed, chances are that those who are able to seek creative ways to collaborate, cooperate, and improvise are more likely to stand a higher chance of survival (Darwin, 1859).

Anecdotal reports suggest that creative spells for many artists are catalyzed through interpersonal attachments, with muses inspiring the most creative works of Pablo Picasso, Friedrich Nietzsche, and Salvador Dalí (cf. Griskevicius, Cialdini, & Kenrick, 2006). The scientific literature has confirmed such anecdotes for more mundane forms of creativity, with different types of interpersonal cues sparking creative behaviors. To name a few, these cues may pertain to the mimicry of an interaction partner (Ashton-James & Chartrand, 2009), the activation of power concepts (Sligte, De Dreu, & Nijstad, 2011), the increased salience of mating motives (Griskevicius et al., 2006), and the priming of sex and love (Förster et al., 2009). For example, Kuhl and Kazen (2008) found that affiliation motives activated recognition of coherent word triads to a greater degree than achievement motives.[1]

3. Cognitive models for relationships

3.1. Embodying social connectedness vs. breaking set

Solomon Asch (1946) first suggested that people's concepts of relationships, and specifically trust and perceptions of psychological warmth of others, are linked to the real experience of physical warmth. Williams and Bargh (2008) provided the first empirical support for Asch's (1958) idea that psychological warmth is anchored in the experience of physical warmth. In two studies, Williams and Bargh (2008) revealed that experiencing a tactile sensation of warmth through holding a cup of warm (vs. cold) coffee or by using a warm (vs. cold) therapeutic pad made people perceive a stranger as having a "warmer" personality or to become more generous in choosing a gift for their friend versus for themselves.

Since Williams and Bargh's (2008) findings, accumulating research further confirmed the function of physical warmth in relationship cognitions. For example, when participants were primed with distance (e.g., through social exclusion, a difference focus, negative communal traits), they estimated ambient temperature to be lower (IJzerman & Semin, 2010; see also Szymkow, Chandler, IJzerman, Parchukowski, & Wojciszke, 2013; Zhong & Leonardelli, 2008). Linking these findings closely to people's representations of relationships, people's internal working models of their relationships also moderate what physical warmth means for individuals. Specifically, young children (aged 4–6) in a warm condition became more generous than their cold counterparts, but *only* if they were securely attached (IJzerman et al., 2013).

Researchers reasoned that people's most basic relationships rely on having an "evolved proclivity" to engage in warm, soothing relationships (see e.g., Bowlby, 1969; Fiske, 1991, 2000; Harlow, 1959). Similar findings have since been obtained with adults. Fay and Maner (2012) found that cues of physical warmth led adult participants to estimate objects as closer, with attachment style serving as an important moderator of the effect. This research on thermal cues offers largely consistent evidence that individuals scaffold their later 're-presentations' (such as mental schemas of love and affection) onto more primitive 'presentations' of the social world (such as a warm touch, indicating that the environment is safe and trustworthy). Acquiring modal knowledge through evolved proclivities thus provides humans with the "pervasive tendency to conceptualize the mental world by analogy to the physical world, rather than the other way around" (Mandler, 1992, p. 596).

The process of building or scaffolding complex knowledge onto basic experiences may explain why thermal cues are linked to even very abstract representations of relationships. For example, more recent findings extended that thermal cues underlie even more complex cognitions and behaviors: People rent more romantic movies (Hong & Sun, 2012), are friendlier towards customers (Kolb, Gockel, & Werth, 2012), and are more nostalgic (Zhou, Wildschut, Sedikides, Chen, & Vingerhoets, 2012) when they feel cold. Together, research has amassed broad empirical support pointing to a close link between thermal cues and mental representations of relationships, with some theorists even suggesting that humans are evolutionarily prepared to seek warmth (e.g., Harlow, 1959; IJzerman & Koole, 2011).

4. A situated model of creative cognition

We have discussed a grounded cognitive framework of relationships, in which people's relationship cognitions frequently rely on thermal cues. Given the extent of knowledge on how interpersonal cues inspire creative performance, the current research sets out as an empirical attempt to bridge the grounded cognitive model of relationships with creative cognition. We will discuss how some forms of mundane creativity rely on the ability in identifying relationships and forging connections between stimuli, while other forms of mundane creativity rely on the ability in breaking away from existing knowledge and switching flexibly between mental categories. As such, these two forms of mundane creativity will benefit significantly from assuming a focus on aspects of relationship or breaking set, respectively.

4.1. The warmth of forging connections: relational creativity

We propose that a focus on relationships and associations benefits the kind of creativity we call *relational* creativity, which requires a relatively simple recognition of interrelatedness (cf. Kray et al., 2006). This view on interrelatedness is supported by converging support from different literatures. Relative to people whose culture emphasizes independence (construing the self as a separate, autonomous entity), people whose culture emphasizes interdependence (embedding the self in a broader collective) recognize perceptual relationships to a greater degree, by categorizing objects on the basis of interrelatedness (Ji, Peng, & Nisbett, 2000), perceiving Rorschach cards as patterns (Abel & Hsu, 1949), and detecting changes in relationships more sensitively (Masuda & Nisbett, 2001; q.v., IJzerman & Semin, 2009). Experimental evidence also confirms a causal link: Making salient the concept of interdependence induced a relational focus in the Navon task, with

[1] Sligte et al. (2011) reported differences between their manipulations and those of Kuhl and Kazen's (2008) and speculated that Kuhl and Kazen's (2008) findings are due to operationalizing power as a personality motive. However, Kuhl and Kazen (2008) reported the *priming* of affiliation versus achievement motives and found that affiliation motives increase recognition of coherent word triads (in comparison to achievement motives). As such, and in contrast to Sligte et al. (2011), we interpret their findings that affiliation increases interdependence to a greater degree and therefore recognition of relational elements.

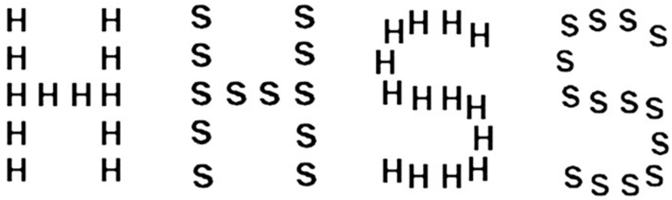

Fig. A.1. Example letters in a Navon Task. Larger letters are typically conceived of as global matches, whereas smaller letters are typically conceived of as local matches.

participants reacting faster to the larger letter in Fig. A.1 when primed with "we" as opposed to "I" (Kühnen & Oyserman, 2002; Kühnen et al., 2001).

In line with this relational view of perception, Kray et al. (2006) reported that creativity often relies on identifying and forging conceptual relationships between existing stimuli. In a series of five experiments, they found that counterfactual thinking, a structured style of thinking that involves the logical consideration of relationships and connections between events in order to appraise what might have been in an alternate reality, promotes a mindset that focuses on forging connections. Such a mindset may be highly conducive for tasks that require a processing style with a detection of logical relationships (e.g., identifying an atypical exemplar as belonging to a conceptual category, such as categorizing a *camel* as a *vehicle*). That thermal cues might facilitate such relational creativity is supported by IJzerman and Semin's (2009) finding where participants in a physically warm (vs. cold) situation saw greater relationships in perceptual foci tasks (i.e., "A" in Fig. B.1) and used a greater amount of verbs.

Interestingly, Kray et al. (2006) further revealed that the facilitative effect of a counterfactual mindset on the ability to forge connections did not apply to creativity tasks that require set-breaking, such as the task that asked participants to exercise their imagination by drawing an alien creature from another planet. Thus, creativity is a relatively elusive and nuanced concept, with some form of creativity requiring the detection of associations (what we have called relational creativity) and some form of creativity requiring the disconnection from prior knowledge and current focal mental categories. This latter form of creativity, what we call *referential* creativity, underlies a seemingly more complex ability to distinguish between local and global features of a stimulus.

4.2. The cold solitude of inventive performance: referential creativity

The ability to break set is captured by the famous "9 dot" creative insight problem in which people attempt to connect all of the dots in Fig. C.1 in four straight lines without lifting the pen from the paper and retracing any lines. One can solve this problem by adding two

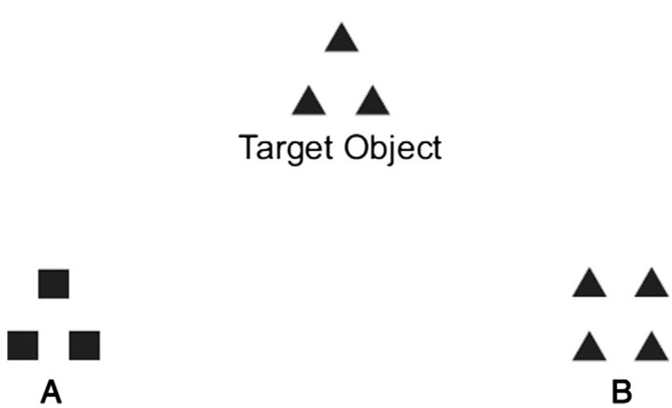

Fig. B.1. An example used in the perceptual-focus task (e.g., Gasper & Clore, 2002). The choice of "A" indicates a global match and the choice of "B" indicates a local match.

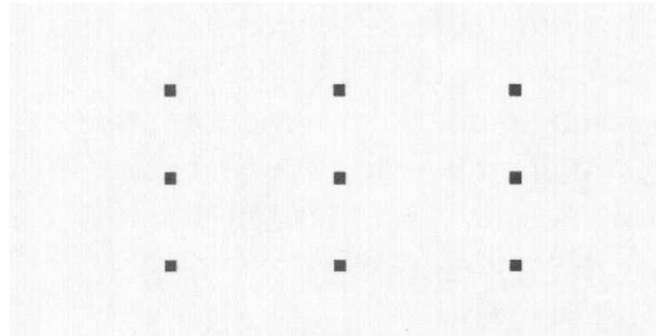

Fig. C.1. The 9-dot problem.

hypothetical dots outside the box (Fig. C.2). The "9 dot" problem exemplifies the importance of the advice to 'think outside the box,' which appears as one of the most enduring and important metaphors for creativity used to inspire young scientists, industrial designers, and Hollywood scriptwriters alike. The wisdom of this out-of-the-box thinking metaphor emphasizes the capacity of creative individuals to destabilize a habitual mental set, to not be tied down by prior knowledge and context (Smith & Blankenship, 1991). Just like solving the "9 dot" creative problem, people who succeed go beyond the nine dots given, loosen the barrier imposed by existing information, and break set by considering the possibility of adding hypothetical dots outside the confines. This ability to break away from mental barriers attests to the different nature of referential (vs. relational) processing.

Applying this logic to understand how referential processing benefits creative cognition, research has confirmed that a related process, namely by manipulating a more proximal or distant perception, activated local or global processing and thereby impeded or facilitated creative deal-making in a negotiation task, respectively (Henderson, Trope, & Carnevale, 2006). Specifically, in one study participants were led to believe that they were to engage in a live negotiation with another partner in the current experimental session or one month later, thus manipulating them to undergo a more proximal or more distant interpersonal experience of the event. The researchers suggested that the proximal interpersonal experience results in people considering the negotiation issues "in a localized, piecemeal fashion rather than in a more integrative, packaged fashion" (p. 718), and that such style of local processing impedes creative deal-making and the attainment of win-win situations for both parties. Results of three studies were affirmative of this prediction. Finally, very direct support comes from research on social rejection: Following social rejection, participants become more creative, an effect driven by a differentiation mindset (Kim, Vincent, & Goncalo, 2013).

In line with the case of warmth forging connections, the opposite thermal cue of coldness appears to aid people to break set: Steinmetz and Mussweiler (2011) reported that people in a cold (vs. warm) condition contrasted (vs. assimilated) to a greater degree from a target figure.

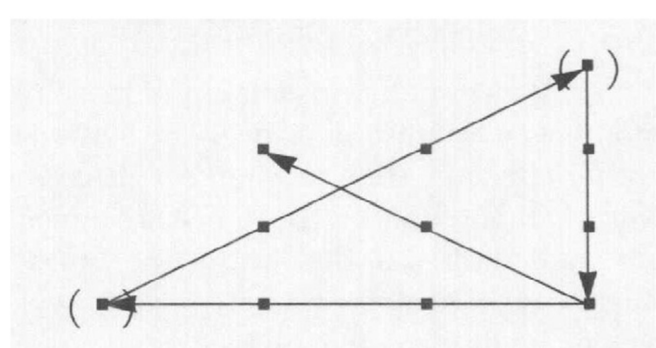

Fig. C.2. Solving the 9-dot problem.

We interpret this as a way to distance, or "breaking set," from the target figure, which may allow individuals to break set from the ideas that were earlier presented to them and therefore focal in their mind.

5. Summary

Together, the literatures we discussed above support Fiske's (1992) theorizing that Communal Sharing relationships are activated through very basic (embodied) cues and that cues of physical warmth (coldness) trigger feelings of psychological connectedness (distancing). To summarize our theoretical arguments, we propose a situated model of creative cognition where a relational-type of creativity is associated with a tendency to perceive relationships and detect associations, and a referential-type of creativity is associated with a tendency to breaking set from prior focal information. Thus, we hypothesized that experiences of physical warmth would facilitate performance in relational creativity tasks and experiences of physical coldness would facilitate performance in referential creativity tasks. We sought to systematically test the model across different manipulations of physical warmth, across different samples, and across different creativity tasks, so as to robustly demonstrate the breadth and generalizability of the hypothesized effects.

6. Overview of studies

We tested our hypotheses in four experiments. In our first experiment, we manipulated physical warmth through ambient temperature amongst a Dutch kindergarten sample (aged 4–6) and administered a drawing task from the Torrence Task for Creative Thinking. We expected that children in the physically warm (vs. cold) condition would display a higher level of interconnections in their drawings (e.g., a cow drawn together with a farm), thus reflecting more adept performance at relational creativity (in this experiment, we did not have a clear hypothesis concerning referential creativity, as discussed later we had a hunch that this type of creativity may come with later age). In our second experiment, we had Singaporean students (aged 19–26) hold a warm or cold therapeutic pad, and expected that those in the physically cold (vs. warm) condition would react faster in recognizing conceptual metaphors after habitually responding to factual statements. This would imply that they displayed greater cognitive flexibility, thus reflecting more adept performance at referential creativity.

In the third experiment, amongst a Dutch university student sample (aged 17–26), we handed participants either a warm or cold cup of tea (IJzerman & Semin, 2009; Williams & Bargh, 2008) and measured their creative performance with both an idea generation task (a pasta naming task) and a conceptual inclusion task (a Category Inclusion Task; see also Kray et al., 2006). We expected that participants would become more inclusive in their categorizations under the physically warm condition, but more original in their idea generations under the physically cold condition. In our fourth experiment, we manipulated physical warmth among a Dutch student sample (aged 18–27) again through having participants hold their wrist against a warm or cold pad. We expected that participants would generate more creative gifts for friends and strangers in a warm (vs. cold) condition, but more abstract (and thus distant) gifts in the cold condition. For all our studies, no intermediate analyses of the data were conducted, while no variables or experiments were dropped that were of interest to the present paper.[2]

With an Asian sample in the second experiment and European samples in the other experiments, we did not predict any cultural differences as we submit that the connections between cues of physical warmth and processing styles tend to operate at a very basic level. Together, this package seeks to offer systematic empirical support for a situated model of grounded creative cognition. Finally, we would like to note that we see the present work as a first exploration in how the body is intimately connected to creative processes, with further replications and extensions necessary to seek confirmations.

7. Experiment 1: warmer children create relational drawings

In our first experiment, we set forth to explore whether the experience of physical warmth could facilitate children's performance in a drawing task which requires an ability to forge connections among distinct elements. In so doing, we employed the figural test of the Torrance Tests of Creative Thinking (TTCT). The figural test of the TTCT requires very little linguistic ability from the participants, and has demonstrated reliability in predicting performance twelve years after taking the TTCT amongst high school students (Torrance, 1972). A recent 40-year study showed that the TTCT also predicts creative performance over longer periods of time (Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005).

7.1. Participants and design

Sixty (43.3% female, $M_{age} = 5.08$, $SD_{age} = .59$, all native Dutch) children aged four to six were recruited from kindergarten classes at two elementary schools in Abcoude, the Netherlands. For all children, we obtained informed consent from their parents/caregivers to participate. They received stickers and balloons upon completion of the study. One child was excluded from analyses, as the task was too difficult for him to complete. Children were randomly assigned to either the physically warm ($N = 30$) or cold ($N = 29$) condition. We used funneled debriefing procedures to probe participants' suspicion (cf. Bargh & Chartrand, 2000). No participants indicated suspicion about the true purpose of the study.

7.2. Procedure

An experimenter (blind to the purpose of the experiment) escorted the children to a room located in their elementary school, which was either warmed up with an electric heater (warm condition; 21–26 °C) or cooled down with air-conditioning (cold condition; 15–19 °C) prior to the start of the experiment (cf. IJzerman & Semin, 2009).[3] In order to enhance efficiency of the data collection process, the warm and cold temperature conditions were run per half day (morning vs. afternoon) and counterbalanced across days. Upon entering the warm or cold room, the participants completed the TTCT adapted for children. They were presented with ten incomplete stimulus figures, which they had to complete into a drawing (see Figs. D.1 and D.2). The participants' drawings were rated by two independent raters on (a) fluency ($r = .52$, $p < .01$), (b) flexibility ($r = .35$, $p < .01$), and (c) originality ($r = .58$, $p < .01$) according to the coding scheme of the TTCT (we did not ask for the generation of picture titles as in the original version of the TTCT). Fluency was measured based on a simple count by one rater on the number of *relevant* ideas presented (e.g., black spots in relation to a cow, a grass field in relation to a farm; an ice cream cone in the mouth of a cow would be irrelevant. Exact repetitions and incomplete scribbles were not counted. See Figs. D.1 and D.2 for a fluent and a non-fluent drawing, respectively). Flexibility was measured based on a count of how many *different* ideas there were in the drawings. Originality was measured based on the unusualness of the ideas reflected by how infrequent ideas appeared as compared to other children in

[2] In our Study 4, we did include a paper-and-pencil task of the perceptual focus task employed by IJzerman and Semin (2009). Typically, this was offered randomly on computer screens, and we thus included it here for exploratory purpose (though it did not render significant effects). In addition, we also included an individual difference measure on self-perceived creativity for the same purpose. Interested researchers may request the data of these measures.

[3] As part of the study, we also conducted another experiment, reported elsewhere (IJzerman et al., 2013). In that experiment, we were interested in how attachment styles modulate cues of physical warmth. The children participated in this experiment *after* the present task. We found in the experiment that securely attached children became more generous than insecurely attached children in a dictator game. We measured attachment styles prior to the creativity task, but only let the children participate in the dictator game afterwards.

Fig. D.1. Drawing provided by a participant scoring high on fluency.

Fig. D.2. Drawing provided by a participant scoring low on fluency.

the sample (as assessed by categorizing the idea and counting them as compared to the ideas provided by other children).

Given that the way of assessing fluency captures the number of relevant ideas related to one another within the TTCT (which we interpret as *relational* in nature), we hypothesized that physical warmth would induce a greater tendency to draw more fluent drawings, but we did not expect these children experiencing warmth to be more flexible or unusual in their drawings.

7.3. Results

In line with our expectation, "warm" children ($M = 2.21, SD = 1.13$) generated marginally significantly more fluent drawings than "cold" children ($M = 1.71$, $SD = .77$), $F(1, 58) = 3.91$, $p = .053$, $\eta_p^2 = .06$ (Cohen's $d = .51$).[4] The analyses did not yield effects on flexibility ($F(1, 58) = 1.63, p = .21$) and originality ($F < 1$).[5]

7.4. Discussion

In our first experiment, concordant with our relational creativity hypothesis, children displayed greater associations in their drawings when primed with interconnections through physical warmth. While we suspected a null effect, we did not have a clear prediction on whether the children could display more set breaking ideas under the cold condition. An important reason for our suspicion is due to the age and learning stage of the sampled children, in that our relatively young participants might not have acquired the skillset for referential creativity and breaking away from existing knowledge structures. In line with what we think about the different processes underlying relational and referential creativity, Torrance (1990; unpublished work cited in Cramond et al., 2005) found little correlation between figural and verbal creative performance, which seems to further confirm that there are different processes upon which individuals draw in performing creatively.

One of the underlying ways for people to learn about how to break set from existing knowledge structures may well be language. As the children in our sample were aged 4 to 6, they have yet to receive much formal schooling. Prior research has indicated that formal schooling further develops reading and language abilities, which help to improve one's ability to abstract thoughts (typically needed for breaking set or mental distancing; Klein et al., 2010). Indeed, we primed the children with a very basic modality-specific mental model. Some scholars argue that a key function of language is to "provide escape from this primary level of thought." Language may thus provide a bridge from experience to abstract thinking, thereby enabling people to supersize their very basic cognitive toolkit (see e.g., Hampton, 2002; IJzerman & Foroni, 2012). It is reasonable to argue that referential creativity requires more advanced knowledge of abstracting one's basic physical world because it involves the capabilities to imagine what is not immediately out there and to go beyond existing ideas (see, for example, the extent literature on construal level theory; Trope & Liberman, 2010). Thus, we expected that sampling an older age group might elicit effects on both the seemingly simpler forging of relationships and the more complex distancing from existing ideas.

In the next experiment, we sought to test the idea that cold temperature indeed primes set breaking amongst older individuals (a student sample) and facilitates their ability to break set from existing knowledge structures. We hypothesized that "cold" individuals benefit from flexible thoughts in a metaphor recognition task. We developed this task to capture how quickly people can switch from one mindset (processing of factual statements) to another (processing of metaphorical statements). If cold temperature enables individuals to break their mental set and think flexibly, we should see "cold" participants reacting faster to recognize the meaning of metaphorical statements after they have been habitually exposed to factual statements, with the task requiring them to differentiate whether these statements were true or false.

8. Experiment 2: cold individuals break set better

8.1. Participants

Sixty students (75% female, $M_{age} = 21.42$, $SD_{age} = 1.67$) from Singapore Management University participated in a laboratory study in exchange for S$5. Participants were randomly assigned to either the warm ($N = 33$) or cold ($N = 27$) therapeutic pad condition.

8.2. Procedure

Participants were ran two at a time in separate individual cubicles. They were informed that the experimental session was a combination of two ostensibly unrelated studies. To the participants, the first study was to serve as a pilot test to verify the effectiveness of a therapeutic pad for an upcoming study, while the second study examined the process of how people made simple judgments through a computer reaction time task. In the first part of the study, participants were asked to try out either the warm or cold pad for three minutes, after which

[4] All Cohen's *d*s were calculated using Becker's Effect Size Calculator (http://www.uccs.edu/~faculty/lbecker/).

[5] We only rated the first four drawings, as our attrition rate exceeded 20% consistently after the first four drawings. Including the remainder of the drawings, however, yielded very similar effects. Children in the warm condition scored marginally higher on fluency ($F(1, 57) = 3.08$, $p = .08$), while there were no effects on flexibility ($F(1, 57) = 1.21, p = .28$) and originality ($F(1, 57) < 1$). The temperature conditions did not affect the children's persistence on the tasks ($F < 1$).

they wrote down their estimation of the pad's temperature in degrees Celsius ($M_{\text{warm}} = 39.81$, $SD_{\text{warm}} = 10.02$ vs. $M_{\text{cold}} = 8.30$, $SD_{\text{cold}} = 4.63$; $F(1, 58) = 226.75$, $p < .01$, $\eta_p^2 = .80$, Cohen's $d = 4.04$).[6]

Participants then proceeded to the computer task programmed with DirectRT software, which involved responding "true" or "false" to some statements by pressing the designated key as quickly as possible. These statements (in black) were presented with size 40 Arial font in the center of the computer screen with white background. Each statement stayed on the screen until the corresponding key was pressed. Unbeknownst to the participants, the first half of the task involved 30 factual statements (e.g., "Some birds have features" and "All tables are round"; half of the statements are true), whereas the second half involved mainly metaphorical statements (e.g., "Some professors are textbooks" and "Some drivers are a compass"; metaphors were adapted from Glucksberg, Gildea, & Bookin, 1982).

Prior to conducting the present experiment, we carried out a pilot test among eleven college students in Singapore to choose which metaphors to include. The pilot test presented 30 metaphorical statements and asked the participants (a) to decide whether these statements are true or false, (b) to indicate on a scale from 1 (*extremely easy*) to 7 (*extremely difficult*) how easy it is to grasp the intended meaning of each metaphor, and (c) to use one word or a short phrase to describe the intended meaning of each metaphor. In the current experiment, we included only those metaphors that were indicated true and understood with the correct intended meaning by all participants. The participants also found it relatively easy to grasp the intended meaning of these metaphors, with the ease ratings for the 30 metaphors ranging from 2.09 to 3.91. Although the ease ratings of all metaphors are below the scale midpoint (4), we chose the 24 metaphors (see below) with the lowest ratings. This is to minimize the confounding factor that the slower response to the metaphorical statements was a result of these metaphors being difficult to understand (as opposed to participants having difficulty switching interpretative frames between factual and metaphorical statements).

The metaphors could only be recognized as true when participants were able to mentally process the conflict between the false literal and true non-literal meanings. To avoid participants habitually answering either true or false to all metaphorical statements, we included three statements that are factually false and three that are factually true in the midst of the 24 metaphorical statements. After a practice trial, participants responded to the 60 statements. Finally, participants filled out some demographic items and were debriefed.

This computer task was designed to examine how fast individuals can flexibly switch their mental set initially geared towards interpreting factual matters to making sense of metaphoric expressions. We posit that individuals who fixate their interpretative frame to discern apparent factual truth will have more difficulty deciphering the relatively more obscure meanings encoded in the metaphors. In other words, performing well in the task requires one to exert some sort of mental distancing from familiar and habitual thought processes and to exhibit cognitive flexibility to break one's mental confines.

8.3. Results

8.3.1. Reaction time to factual and metaphorical statements answered correctly

Average reaction times (RTs) to factual and metaphorical statements were separately computed after excluding those that were two or more standard deviations away from individual means. To test the idea that cold sensation better promotes mental distancing from habitual thought processes, we computed the RTs of only those factual and metaphorical statements that were answered correctly. These two RTs were first submitted to the 2 (within-subject factor: factual vs. metaphorical statements) X 2 (between-subjects factor: warm vs. cold pad) repeated measures ANOVA.

Results revealed that participants responded faster to factual ($M = 1615.61$, $SD = 509.83$) than metaphorical statements ($M = 1969.30$, $SD = 660.47$), $F(1, 58) = 52.94$, $p < .01$, $\eta_p^2 = .48$ (Cohen's $d = -.59$). This statement main effect was qualified by our expected two-way interaction, $F(1, 58) = 10.91$, $p < .01$, $\eta_p^2 = .16$. Participants reacted equally fast towards correctly answered factual statements under cold ($M = 1616.76$, $SD = 501.66$) and warm ($M = 1614.66$, $SD = 524.18$) conditions, $F(1, 58) < .01$, $p = .98$, but they reacted marginally significantly faster towards correctly answered metaphorical statements under cold ($M = 1801.50$, $SD = 546.39$) as compared to warm ($M = 2106.59$, $SD = 720.09$) conditions, $F(1, 58) = 3.29$, $p = .08$, $\eta_p^2 = .05$ (Cohen's $d = -.48$). No main effect of pad condition was detected, $F < 1.10$, $p = .30$.

8.3.2. Error rates in responding to factual and metaphorical statements

Besides reaction time, another meaningful analysis concerns how much error participants made in responding to factual and metaphorical statements under the different temperature conditions. We computed the error rates (in percentage) in participants' responses to the two types of statements and submitted them to the 2 (within-subject factor: factual vs. metaphorical statements) X 2 (between-subjects factor: warm vs. cold pad) repeated measures ANOVA. As expected, participants made more errors in responding to metaphorical ($M = 40.35$, $SD = 28.94$) than factual statements ($M = 8.39$, $SD = 7.38$), $F(1, 58) = 66.03$, $p < .0001$, $\eta_p^2 = .53$. The two-way interaction was marginally significant, $F(1, 58) = 2.99$, $p = .09$, $\eta_p^2 = .05$. If there is anything, there is a trend that "cold" participants made less errors in recognizing metaphorical statements ($M = 34.26$, $SD = 25.82$) than "warm" participants did ($M = 45.33$, $SD = 30.76$), $F(1, 58) = 2.22$, $p = .14$, $\eta_p^2 = .04$, although the "cold" participants made slightly more errors when responding to the factual statements ($M = 9.63$, $SD = 5.18$) than their "warm" counterparts ($M = 7.37$, $SD = 8.73$), $F(1, 58) = 1.40$, $p = .24$, $\eta_p^2 = .02$. No main effect of pad condition was detected, $F < 1.33$ $p = .25$.

8.4. Discussion

In our second experiment, we examined whether cold conditions (as compared to warm conditions) would facilitate breaking set from previously activated knowledge structures, by testing whether adult participants would respond quicker to metaphorical statements after habitually answering factual statements. We found that this was indeed (marginally) the case.

The use of a task-switching methodology to compare the switching cost between cold and warm conditions highlights the cognitive flexibility that our cold condition provides. While cognitive psychologists acknowledge the ability to switch task to signal the flexibility of cognitive control, Zabelina and Robinson (2010) provided a direct link between flexible cognitive control and creativity. Utilizing a Stroop task, these authors found creative individuals to demonstrate greater cognitive control modulation across trials. Specifically, the Stroop effect within such individuals was greater (lesser) if they encountered an incongruent trial that was preceded by a congruent (incongruent) trial. Adding onto their finding, our result indicates that such cognitive flexibility or set breaking can be achieved when in cold conditions.

Importantly, one might argue that recognizing the conceptual links between different elements in a metaphor may occur more rapidly in physically warm conditions. To further understand the reaction time patterns towards the metaphors presented, we plotted the average

[6] One may note that this experiment is one out of two experiments in the current research in which we asked participants for their temperature perception. Typically, we tend not to ask it as a manipulation check anymore, because of the enormous effect sizes. For example, IJzerman and Semin (2009) found the difference in the manipulation check between warm and cold conditions to be $\eta_p^2 = .85$. In the second and fourth experiments, we asked the temperature perception because it was part of the cover story of those studies. Again, the effect size ranged from large to huge (Experiment 2: Cohen's $d = 4.04$; Experiment 4: Cohen's $d = 1.8$).

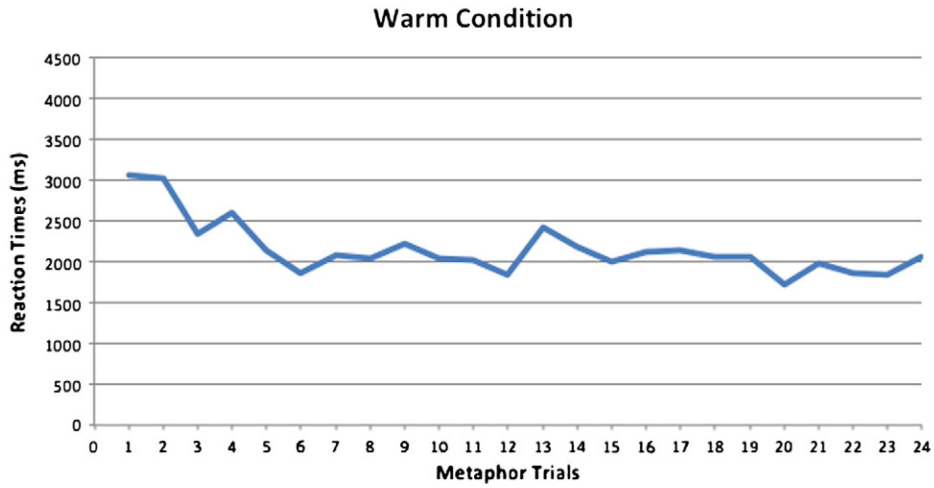

Fig. E.1. Average reaction time of each metaphor trial (Warm condition).

reaction time per trial for both warm and cold conditions. From Fig. E.1, we can see that although participants in the warm condition tended to react slower in the first two presented metaphors, they eventually adjusted to the switch and were faster in the subsequent trials. Contrastingly, participants in the cold condition tended to react much faster in the critical first few trials as well as across all subsequent trials (Fig. E.2), further supporting that they were more cognitively flexible in adjusting to the mental switch. In light of the first two experiments, the third experiment extended both studies by testing *both* the relational and referential creativity hypotheses in one single adult sample.

9. Experiment 3: warm and inclusive, but cold and original

In Experiment 3, we used a different methodology to manipulate physical warmth by having the experimenter ask the participants to hold either a warm or cold cup of tea for him/her (Williams & Bargh, 2008). Recall that in Experiment 2, as a cover we presented the temperature manipulation as a pilot test for assessing the pad's effectiveness and that allowed us to ask the temperature manipulation check question. As the current experiment adopted a different temperature manipulation, asking the temperature question would be out of context. In addition, as this question was asked prior to the dependent variables, omitting it could not have primed participants to consciously think about warmth or coldness through associative links.

Next, participants completed three tasks commonly used to measure processing styles implicated in creative performance: The Category Inclusion Task (Rosch, 1975; see also Isen & Daubman, 1984), a task for creating new names for a new type of pasta (Marsh, Ward, & Landau, 1999), and the Remote Associates Test (RAT; Mednick, Mednick, & Mednick, 1964). We hypothesized different effects of physical warmth on these tasks. First, seeing greater connections between a category (e.g., vehicle) and an exemplar (e.g., camel) benefits from greater relational processing (Kray et al., 2006; Rosch, 1975; see also Isen & Daubman, 1984). We expected that "warm" (vs. "cold") participants would be more inclusive in their categorization in the Category Inclusion Task. Second, creative performance in the pasta-naming task depends on whether individuals can come up with original names that sufficiently deviate from the provided examples (e.g., Dijksterhuis & Meurs, 2006). This generation of new pasta names requires one to readily break set from prior knowledge, an ability that involves the use of referential processing. We therefore expected that physical coldness (vs. warmth) would facilitate creative performance in the pasta-naming task.

Third, the RAT is often used as an insight creativity task (e.g., Griskevicius et al., 2006; Schooler & Melcher, 1995), which requires individuals to *forge* associations from a triad of words, as well as *breaking set* from a common denominator from the set (e.g., identifying *table* as the common link for the words *manner* – *tennis* – *round*).

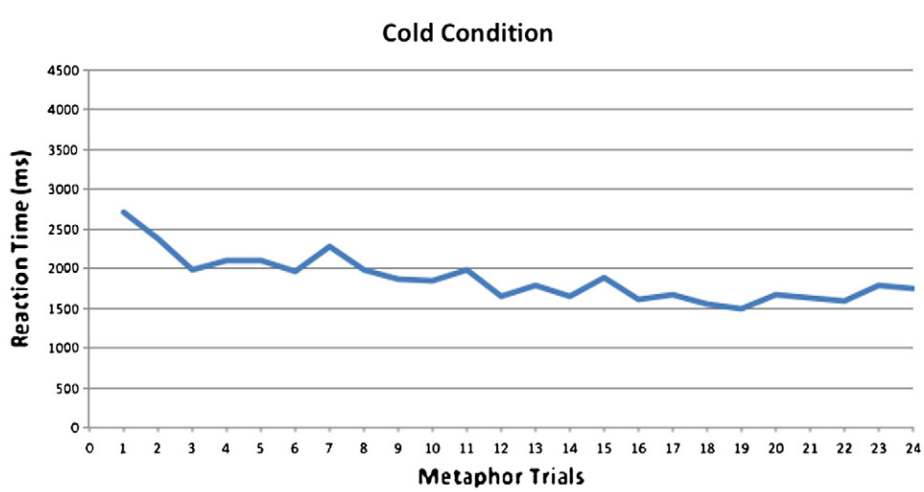

Fig. E.2. Average reaction time of each metaphor trial (Cold condition).

Given that the RAT relies on forging relational associations *and* abstracting a common denominator, both relational and referential creativity is required to excel in the task. In line with our predictions, we expected that while warm temperatures benefit forging associations, cold temperatures benefit abstracting a common denominator. Given that our between-subjects temperature manipulation mainly activated one mode of processing, we did not expect the temperature prime to pan out an effect on RAT performance.

9.1. Participants and design

Fifty-six native Dutch VU University students (64.3% female; $M_{age} = 20.4$, $SD_{age} = 2.04$) took part in a computerized experiment in exchange for €3.50. Participants were alternately allocated to the warm ($N = 23$) or cold ($N = 33$) condition. Consistent with earlier research, we only chose participants from a homogeneous group (cf. IJzerman & Semin, 2009, 2010; IJzerman, Regenberg, et al., 2013). Conditions were therefore not equal in numbers.

9.2. Procedure

Participants were ran one at a time. Upon arrival to the lab, the experimenter, while ostensibly drinking a glass of (warm or cold) tea and holding a stack of experiment-related documents, greeted the participant, and led him/her to a computer-equipped cubicle. Under the cover that she would need to install the right version of the program on the computer, the experimenter asked the participant to briefly hold her glass of tea. It was highly unlikely that the experimenter who held the cup of warm or cold tea would bias how the participants would respond to the various dependent measures, given that the experimenter did not have any interaction during the completion of tasks. Alternately assigned to either one of the two temperature conditions, twenty-three participants held a glass of warm tea and thirty-three held a glass of iced tea.

Participants first rated their mood on a slider ("How positive or negative do you feel at this moment"; from 0 = *very negative*, through 50 = *neutral*, to 100 = *very positive*) as well as on other positive (6 items, e.g., "At this moment, I feel good"; Cronbach's $\alpha = .81$) and negative affect items (6 items, e.g., "At this moment, I feel bad"; Cronbach's $\alpha = .83$) (for all items, they had a 7-point scale from 1 = *not at all* to 7 = *very much*; Williams, Cheung, & Choi, 2000; Zadro, Williams, & Richardson, 2004).

Next, participants completed two counterbalanced tasks (RAT and pasta-naming task) and finally the Category Inclusion Task. The RAT involved 15 items (five low, five medium, and five high difficulty items). In the pasta-naming task, we adapted the task by providing some existing names for pasta (e.g., lasagna, spaghetti, fettuccini, rigatoni) and asking participants to generate as many new names as they could for a specific type of pasta that is to be introduced to the market (see Dijksterhuis & Meurs, 2006; Marsh et al., 1999). In the 14-item Category Inclusion Task, participants rated the degree to which specific examples belong to a general category (e.g., "To what degree is a camel a vehicle?"; 1 = *definitely does not belong to the category*, 7 = *definitely belongs to the category;* Cronbach's $\alpha = .66$). Finally, participants completed some demographic items, were debriefed, paid, and thanked for their participation.

9.3. Results

First, we checked if temperature affected mood ratings. As expected and consistent with earlier works (IJzerman & Semin, 2009; Kolb et al., 2012; Williams & Bargh, 2008), there were no effects of temperature conditions on general mood and positive and negative affect (all *p*s > .14). We then averaged all items of the Category Inclusion Task to obtain an average inclusion score. As predicted, participants who had held a warm cup ($M = 3.92$, $SD = .62$) were more inclusive in their categorization than participants who had held a cold cup ($M = 3.50$, $SD = .59$), $F(1, 54) = 6.45$, $p = .01$, $\eta_p^2 = .11$ (Cohen's $d = .70$).[7] Consistent with other work on procedural priming, this effect was not due to mood: The same temperature effect on category inclusion remained after including either the one-item general mood measure ($F(1, 53) = 5.28$, $p = .03$), positive affect ($F(1, 53) = 6.35$, $p = .02$), or negative affect measures ($F(1, 53) = 6.49$, $p = .01$) into the analyses.

For the pasta-naming task, we rated the new pasta names on originality and fluency. Originality was scored based on how novel each name was. Given that we provided participants some existing pasta names (e.g., lasagna, spaghetti, fettuccini), we scored originality in four categories: (a) names that have a similar beginning and a similar ending (e.g., "lasaccini"), (b) names that have a similar beginning, but a different ending (e.g., "fettupo"), (c) names that have a different beginning, but a similar ending (e.g., "totuccini"), and (d) names that have neither a similar beginning nor ending (e.g., "potsipano").

For each participant we tallied the frequency counts of names for each of the four categories and divided the frequency score for each category by the total number of names generated in the sample (i.e., the total number of names generated across the four categories). This score thus reflects how often the category occurs *as compared to the other participants* refined by the type of category. Thus, each category came out with a score (completely different: .76; similar beginning: .017; similar ending: .20; same beginning, same ending: .011). If a name belongs to a particular category, we assigned that name the score of that category. We then averaged these scores across the names participants generated, and then multiplied this summed score by 100 (for exact coding instructions, see our supplemental materials, submitted to Tilburg Dataverse upon acceptance of the paper).

As a consequence, for this measure, the lower the score, the more likely the generated names were of higher originality and greater deviation from the existing pasta names as compared to the general 'norm' amongst the rest of our participants (note that this does not necessarily mean "different" from the example). Consistent with our hypothesis, participants in the physically cold condition ($M = 53.88$, $SD = 23.65$) generated more original pasta names as compared to the rest of the sample than participants in the physically warm condition ($M = 69.06$, $SD = 16.65$), $F(1, 54) = 7.03$, $p = .01$, $\eta_p^2 = .12$ (Cohen's $d = -.74$).[8] This confirms our prediction that coldness facilitates breaking set, as lower scores denote higher deviation from the other participants, suggesting that "cold" participants were more counter-normative than their "warm" counterparts.

Fluency was scored in terms of the total number of pasta names participants generated. Temperature had no effect on participants' fluency score ($F < 1$). We suspect that this might be due to frequency being a poorer indicator of out-of-the-box thinking than originality, which was based on how likely the new pasta names deviated sufficiently from existing ones. As for RAT, no effect of temperature was found on overall performance ($F(1, 54) = 1.49$, $p = .23$), as well as in separate multivariate analyses of variance on low, medium, and high difficulty items (all *F*s < 1).[9]

[7] Orthogonally, we also primed either an office or home environment amongst our participants to explore differences of the meaning of temperature in different contexts. Although a home environment ($M = 3.86$, $SD = .68$) made participants more inclusive than the office ($M = 3.53$, $SD = .56$), $F(1, 52) = 5.04$, $p = .03$, $\eta_p^2 = .09$, there was no interaction effect between environment and temperature conditions, $p = .99$ (with the *p* value of the temperature condition further strengthening to .01).

[8] Although sex had a significant effect on the originality of responses ($p = .04$), it again changed little our hypothesized effect ($p = .01$).

[9] We also included the Unusual Uses Test of a brick for exploratory purpose. Given that we did not think that the generation of unusual uses of a brick to directly tap onto relational or referential processing, we did not expect an effect. Scoring the brick ideas did not involve being more distant in terms of creating new names as in the pasta-naming task. Indeed, there were no effects of temperature on scores of fluency ($p = .24$), elaboration ($p = .65$), and originality ($p = .41$) of the brick task. Although we did not have clear hypotheses, given the discussion in our field on false positives (e.g., Simmons, Nelson, & Simonsohn, 2011), we chose to report this task in our article.

9.4. Discussion

Concordant with our hypotheses, Experiment 3 revealed that the physically warm condition induced greater inclusiveness in categorization, whereas the physically cold condition facilitated the generation of more counter-normative pasta labels. Furthermore, we obtained a null effect on RAT performance probably because the task requires both relational and referential processing, and therefore manipulating either warm or cold thermal cue to activate either relational or referential processing failed to produce differential effects in RAT performance across the temperature conditions. However, we acknowledge that given the sample size in our studies was modest, statistically it could very well be that not obtaining the effect is a fluke (see e.g., Francis, 2012), and that the RAT performance may be able to benefit from relational processing. In addition, we also admit that an alternative (post-hoc) hypothesis could be that participants should generate pasta names that are different from the original example. A priori we predicted that cold conditions should facilitate breaking set and thus being counter-normative, but researchers who would want to engage in follow up research may well want to investigate this issue. Together with Experiments 1 and 2, we see Experiment 3 to offer accumulating support for our propositions that cues of physical warmth lead to greater forging of associations among seemingly unrelated elements and cues of physical coldness lead to breaking set from existing knowledge structures.

10. Experiment 4: warm arms give popular and concrete gifts

In the first three experiments, we primarily focused on cognitive tasks to gather support for the idea on how embodied cues can stimulate processing styles related to creativity. In the final experiment, we extended our work to what mundane creativity seems to bear great relevance to, that is, the social domain, by asking participants to generate gifts for others. Based on previous findings that seeing things from a distance, a way to break set, induces an abstract mindset (e.g., more abstract language use; Fujita, Henderson, Eng, Trope, & Liberman, 2006), in our fourth study we expected "cold" (i.e., more "distant") participants to generate more abstract gifts, thereby demonstrating a higher degree of breaking set from contextualized ideas. In contrast, we expected "warm" participants to generate higher quality gifts for another person, thereby demonstrating a greater ability to forge mental connections with the gift recipient.

In the previous experiment, we have found some indication that thermal cues lead to people being more or less in line with other people's normative responses in generating new pasta names. In the current experiment, we took into account the quality of the gift for the gift recipient, thereby further testing the socially embedded aspect of creative performance. Together, we set forth to further confirm our relational and referential processing hypotheses by examining the different manifestations of creative responses within only one creativity task (i.e., quality vs. abstractness of responses) as opposed to employing different creativity tasks as in Experiment 3. In addition, we included a differentiation between friends and strangers as the gift recipients to explore whether the presence of a "known" relationship would interact with our warmth cue. We expected that known friendship relations should have comparable effects (i.e., thinking of a friend leads to better gifts than strangers) as warmth. It seems logical to assume that the known friendship relation has a greater effect size, which places the effect of physical warmth into its context in human social cognition.

10.1. Participants and design

One hundred and one native Dutch students from Utrecht University (51.5% female, $M_{\text{age}} = 21.85$, $SD_{\text{age}} = 2.27$[10]) were recruited around campus to participate in a paper-and-pencil test, ostensibly testing how a new brand of therapeutic pad would affect concentration. Depending on the condition, the pad was either warmed up in a microwave or cooled down in iced water. We had 52 participants in the cold condition (26 males) and 49 in the warm condition (23 males).[11] Participants were given chocolate in return for their participation.

10.2. Procedure

Under the cover that the study was meant to test a new consumer product (a pad) on its benefits for concentration, participants were asked to try out the pad and do some product ratings at the end of study (e.g., "How effective do you think this pad is", or "Did you feel any discomfort when this pad was placed on your hand"). Before completing the product ratings, they were asked to participate in some tests from a fellow student in psychology. Half of participants were asked to generate as many (good quality) gifts for a friend as possible, whereas the other half were asked to generate as many (good quality) gifts for a stranger as possible in order to explore a potential interaction between temperature and relationship type. In line with earlier research, we did not expect an interaction, as physical warmth should serve as a basic cue for seeking relationships in general (for a similar theoretical reasoning, see IJzerman, Karremans, Thomsen, & Schubert, 2013).

Two independent raters, blind to the experimental condition, rated the gift ideas on quality to the gift recipient on a 1 (*very low quality*) to 7 (*very high quality*) scale (interrater correlation = .91, $p < .001$) and on the concreteness of the gift description on a 1 (*very abstract*) to 7 (*very concrete*) scale (interrater correlation = .78, $p < .01$). Examples of concrete gift descriptions are "a pizza cutter," "mascara that the recipient borrows too often from me," and "a bottle of wine that should be consumed on the side of the canal," while examples of abstract gift descriptions are "personal stuff," "jewelry," and "a gift certificate").[12]

10.3. Results

We conducted a 2 (Temperature condition: warm vs. cold) X 2 (Gift condition: friend vs. stranger) ANOVA on gift quality and gift abstractness. As per logical expectations, participants generated higher quality gifts for (psychologically warm) friends ($M = 4.13$, $SD = .75$) than for (psychologically cold) strangers ($M = 3.02$, $SD = .60$), $F(1, 97) = 66.42$, $p < .01$, $\eta_p^2 = .44$ (Cohen's $d = 1.63$). Importantly, "physically warm" participants ($M = 3.75$, $SD = .87$) generated significantly higher quality gifts than "physically cold" participants ($M = 3.42$, $SD = .87$), $F(1, 97) = 4.04$, $p = .05$, $\eta_p^2 = .04$ (Cohen's $d = .37$), corroborating our relational creativity hypothesis and thus conceptually replicating the link between physical warmth and psychological warmth (in terms of higher gift quality to the recipients overall). There was no interaction between temperature and friend vs. stranger conditions ($F < 1$; see also IJzerman, Karremans, et al., 2013 for similar findings). We also ran the analyses with gender included, which somewhat strengthened our temperature main effect ($p = .04$). There was, however, no interaction effect between temperature condition and gender ($p = .17$).

[10] Of our 101 participants, 82 reported their age.

[11] In order to be able to test for gender effects, note that we continued data collection until the point that cell sizes for males were sufficiently large and roughly equal to the number of females. It was more difficult to recruit male participants around the Social Science building at Utrecht University.

[12] Out of the 101 paper-and-pencil questionnaires, 79 were rated by two independent judges. Twenty-two of the questionnaires were rated once, and were then lost. The first author moved two universities in the meantime, and the person collecting data moved house. In that process, some of the questionnaires were lost (prior to the second rating). Given the high interrater reliability in the rated responses and the fact that when omitting the one-time rated responses, the effects showed were similar, albeit somewhat less strong (interaction effect: $p = .052$), we are very confident that including these one-time rated responses is legitimate.

Similar to gift quality, the distance with the gift recipient made a difference on gift abstractness, with participants generating more concrete gifts for friends ($M = 3.91$, $SD = .69$) than for strangers ($M = 3.24$, $SD = .85$), $F(1, 97) = 17.90$, $p < .01$, $\eta_p^2 = .16$ (Cohen's $d = .87$). Of import, in line with our referential creativity hypothesis, we found that "warm" participants ($M = 3.72$, $SD = .73$) generated marginally significantly more concrete gifts than "cold" participants ($M = 3.44$, $SD = .92$), $F(1, 97) = 2.84$, $p = .095$, $\eta_p^2 = .03$ (Cohen's $d = .34$); in other words, "cold" participants generated more abstract gifts than their "warm" counterparts. We again ran the analyses including the gender variable, which left our effect virtually the same ($p = .09$). There was again no interaction effect between temperature conditions and gender ($p = .17$).

10.4. Discussion

In our final experiment, participants came up with gifts for friends or strangers, performing a more socially oriented creativity task. Regardless of the gift recipients, "warm" participants came up with higher quality creative gifts than "cold" participants. This confirms our relational processing hypothesis, as physical warmth (vs. coldness) embeds participants to a greater degree in their social relations and thus prompts them to generate better quality gifts for giving to others. Interestingly, "cold" participants, on the other hand, came up with more abstract gifts than "warm" participants. This confirms our referential processing hypothesis, as physical coldness (vs. warmth) activates a higher level a distancing mindset, which allows one to break set. In addition, as one may logically expect, we found that participants tend to come up with higher quality as well as more concrete gift ideas for friends as opposed to strangers (i.e., better, more relational gifts for friends, and more distant, "referential" gifts for strangers). Unsurprisingly, the effect size of a known friendship relation is much greater than the one for a very subtle manipulation of physical warmth. In sum, Experiment 4 corroborated our relational and referential processing hypotheses within the context of the same creativity task, thus further establishing the generalizability of our findings.

11. Case based meta-analyses

We sought to create greater confidence from our exploratory studies, by conducting case-based meta-analyses. Following recommendations by Shimmack (2012), we standardized the variables in each study and included both temperature condition and "Study" as predictor variables in an Analysis of Variance, and classified our variables according to Set-Breaking (Study 2: Metaphor RT; Study 3: Pasta Naming; Study 4: Gift Abstractness) and Relational Predictions (Study 1: Fluency; Study 3: Category Inclusion; Study 4: Gift Quality). For our Set-Breaking Prediction, temperature condition was significant, $\eta_p^2 = .058$, $F(1, 216) = 12.90$, $p < .001$ ($Md = .47$, CI_{95} .20–.74; Wuensch, 2012), with no significant effects of Study ($F < 1$) and no interaction effect between Study and Temperature Condition ($F < 1$). For our Relational Prediction, we obtained similar effects, with temperature condition being significant, $\eta_p^2 = .061$, $F(1, 215) = 13.55$, $p < .001$ ($Md = .49$, CI_{95} .22–.76), with no significant effects of Study ($F < 1$), and no interaction effect between Study and Temperature Condition ($F < 1$).

12. General Discussion

Across four experiments, we sought to confirm predictions of our relational and referential processing models in creative cognition through the manipulation of thermal cues. We found that participants in physically warm (vs. cold) conditions forged more relationships in drawing pictures, were more inclusive in their categorization, and generated higher quality gifts for others. Conversely, participants in physically cold (vs. warm) conditions were better able at breaking set from their existing mindset by switching from making sense of factual statements to metaphoric statements, creating more counter-normative names for pasta, and generating more abstract gifts for others. We found our effects in distinctly different samples in terms of cultural backgrounds as well as age groups.

To our knowledge, the current research is the first empirical attempt to examine a grounded model of creative cognition (albeit with relatively modest sample sizes). We encourage additional research, not only through close replications, but also through conceptual replications (see Brandt et al., 2013), testing our model in different (cultural) contexts and with different creativity tasks in order to generalize beyond the present contexts. Although our sample sizes are on the low end, we believe that such labor-intensive projects with relatively small sample sizes *are* useful as a first step, because they have now consistently revealed interesting regularities in terms of how the body influences creative *processes*, setting the stage for carrying out more high-powered (close and conceptual) replication studies. Our case-based meta-analyses do provide some greater confidence that our effects are true, with medium effect sizes. Replications however are crucial prior to applying these results beyond the lab. Importantly, as we found that our effects were obtained in different age groups and cultural contexts, the current research provides an encouraging extension to the present state-of-the-art in research on the embodied quality of thermal cues, which to date has been mostly conducted with college students in the West (for an exception, see IJzerman, Regenberg, et al., 2013).

Our current research goes beyond previous works linking physical warmth and psychological relationships, such as past research that revealed that physically warm cues induce the use of more verbs and the recognition of more relationships in one's environment (IJzerman & Semin, 2009) and that physically cold cues activate a contrast mindset between oneself and others (cf. Steinmetz & Mussweiler, 2011). By extending to the domain of the highly valued creative ability, we gained support for the proposed situated model of creative cognition. Yet, by "situated," we do not mean arbitrary. We predicted specific effects of our model for specific reasons: Relational processing style situated in physically warm contexts largely benefits the kind of creativity that requires forging greater associations among seemingly unrelated elements. Referential processing style situated in physically cold contexts largely benefits the kind of creativity that requires greater flexibility to switch between mental frames and to break set from preexisting knowledge systems. The application of grounded creative cognition seems to serve different specific functions, drawing from different types of perceptual representations.

Notably, we contend that the two processes that we have detected could operate simultaneously, as in the case of performing in the RAT we discussed earlier under Experiment 3. On the one hand, the RAT requires people to use conceptual recombination to recognize and forge associations between seemingly distant word elements (Leung et al., 2012; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2008), which calls for relational processing. On the other hand, the RAT requires abstracting a common denominator from the set of words, which calls for referential processing. Hence, we submit that both relational and referential creativity work hand-in-hand for one to successfully come up with the solution in the RAT. As such, for some creative problem-solving the two processes may well work in tandem (vs. independently) to enhance performance.

Furthermore, beyond warmth influencing complex processing (see for example work on metaphor; Landau, Meier, & Keefer, 2010), an alternative way of approaching the link between physical experiences and abstract mental construal processes is to explore how different sensory stimulations pan out the same cognitive outcome. Research revealed that both warming and cooling the fingers sharpens tactile acuity (Stevens, 1982), though others also found that the perception of apparent roughness decreases if skin temperature falls below normal levels (Green, Lederman, & Stevens, 1979). The exact links between physical experiences and creative processes are thus still very much up for exploration, and the present findings suggest that creative cognition might be energized by not only one, but multiple sources of tactile sensations (feelings of warm and cold). An investigation into these multi-sensory integrations allows for exciting new avenues and insights into the cognitive models of relationships.

In addition, our work also sheds some new light on previous findings in evolutionary psychology. In one study, Griskevicius et al. (2006) primed participants with either short-term or long-term mating motives. They found that both short-term and long-term mating motives increased creativity for men, whereas only long-term mating motives increased creativity for women. In our view, these *cognitive* primes do not simply activate evolutionarily prepared bodily templates related to mating behaviors, but they prime how the two genders have learned to implement their basic relational models differentially. These learning processes thus seem to have important implications for creative behaviors, and we think that some earlier research could be re-investigated in light of our findings.

In future research, we recommend examining different types of creativity, as this may further illuminate the embodied processes of creative cognition. In our experiments, we found effects of physical warmth on very mundane types of creativity. These basic physical experiences seem to be applicable to different individuals equally well (as they seem to apply to very basic evolved models of relationships that are further elaborated upon through life-long learning processes). That is, very similar processes for different individuals seem to occur: Across samples (Singaporeans and Dutch adults and children) we have found an elicitation of creative performance by very basic thermal cues. This seemingly culturally invariant result obtained in the present set of studies may well reflect that universally humans possess, as Fiske (1992) calls them, 'evolved proclivities,' 'pre-wired embodiments,' or 'evolved simulators' (q.v., Cohen & Leung, 2009; IJzerman & Cohen, 2011; IJzerman & Foroni, 2012) to prepare for survival, which may well be the basis for mundane creativity.

Complementing this notion is the idea of variable embodiments, which pertain to the different ways in which people learn to encounter their physical world. That is, extraordinary artists like Picasso or Dali may have integrated perceptual information very differently from and in more complex ways than other less gifted individuals. Future research may seek to illuminate how individuals differently optimize their perceptual symbols to understand daily experiences, tuning their cognitive apparatus to their (different) perceived outer worlds to inspire extraordinary performance (Barsalou & Prinz, 1997).

To close, we want to highlight the value of the grounded cognitive models of relationships to the study of the human mind. The tactile experience of physical warmth seems to be one of the most basic cues through which people learn about their social world. Beyond finding the utility of this grounded model of relationships to the domain of creative cognition, we hope that the current work has shed more light on the essential nature of the body in constituting the mind.

Acknowledgments

This research was partly supported by a Veni grant (016.145.049) awarded to Hans IJzerman by the Netherlands Organisation for Scientific Research and a Tier 1 grant (C242/MSS11S003) awarded to Angela K.-y. Leung via the Ministry of Education Academic Research Fund.

We would like to thank Emma Landstra (Experiment 1), Marina Vetrova (Experiment 3), and Jonas Weijers (Experiment 4) for their hard work in collecting the data. In addition, we would like to thank Lieke van Duist (Experiment 3), Arnoud Plantinga (Experiment 1 and 3), Taketo Pang (Experiment 1 and 4), and Jonas Weijers (Experiment 4) for their help in rating the creativity tasks, the Tilburg Hardcore Labgroup, Ellen Evers, Yana Avramova, and Yoel Inbar, and the editor Michael Kaschak and two anonymous reviewers for their very thoughtful comments on our paper.

References

Abel, T. M., & Hsu, F. L. K. (1949). Some aspects of personality of Chinese as revealed by the Rorschach test. *Rorschach Research Exchange and Journal of Projective Techniques*, *13*, 285–301.

Amabile, T. M. (1996). *Creativity in context.* Boulder, CO.: Westview Press.

Asch, S. E. (1946). Forming impressions of personality. *Journal of Abnormal and Social Psychology*, *41*, 258–290.

Asch, S. E. (1958). The metaphor: A psychological inquiry. In R. Tagiuri & L. Petrullo (Eds.), *Person perception and interpersonal behavior* (pp. 86–94). Stanford, CA: Stanford University Press.

Ashton-James, C. E., & Chartrand, T. L. (2009). Social cues for creativity: The impact of behavioral mimicry on convergent and divergent thinking. *Journal of Experimental Social Psychology*, *45*, 1036–1040.

Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle: A practical guide to priming and automaticity research. In H. T. Reis & C.M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 253–285). New York: Cambridge University Press.

Barsalou, L. W., & Prinz, J. J. (1997). Mundane creativity in perceptual symbol systems. In T. B. Ward, S. M. Smith, & J. Vaid (Eds.), *Creative thought: An investigation of conceptual structures and processes* (pp. 267–307). Washington, D. C.: American Psychological Association.

Bowlby, J. (1969). *Attachment and loss, Vol. 1: Attachment.* London: Hogarth Press.

Brandt, M. J., IJzerman, H., Dijksterhuis, A., Farach, F. J., Geller, J., Giner-Sorolla, R., et al. (2013). The replication recipe: What makes for a convincing replication? Available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2283856

Cohen, D., & Leung, A. K. -y (2009). The hard embodiment of culture. *European Journal of Social Psychology*, *39*, 1278–1289.

Cramond, B., Matthews-Morgan, J., Bandalos, D., & Zuo, L. (2005). A report on the 40-year follow-up of the Torrance tests of creative thinking: Alive and well in the new millennium. *Gifted Child Quarterly*, *49*, 283–291.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention.* New York: Harper Perennial.

Darwin, C. (1859). *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life.* London: John Murray.

Dijksterhuis, A., & Meurs, T. (2006). Where creativity resides: The generative power of unconscious thought. *Consciousness and Cognition*, *15*, 135–146.

Fay, A. J., & Maner, J. K. (2012). Warmth, spatial proximity, and social attachment: The embodied perception of a social metaphor. *Journal of Experimental Social Psychology*, *48*, 1369–1372.

Fiske, A. P. (1991). *Structures of social life: The four elementary forms of human relations.* New York: Free Press.

Fiske, A. P. (1992). The four elementary forms of sociality: Framework for a unified theory of social relations. *Psychological Review*, *99*, 689–723.

Fiske, A. P. (2000). Complementarity theory: Why human social capacities evolved to require cultural components. *Personality and Social Psychology Review*, *4*, 76–94.

Förster, J., Epstude, K., & Özelsel, A. (2009). Why love has wings and sex has not: How reminders of love and sex influence creative and analytic thinking. *Personality and Social Psychology B*, *35*, 1479–1491.

Francis, G. (2012). The same old new look: Publication bias in a study of wishful seeing. *i-Perception*, *3*. (pp. 176–178).

Fujita, K., Henderson, M., Eng, J., Trope, Y., & Liberman, N. (2006). Spatial distance and mental construal of social events. *Psychological Science*, *17*, 278–282.

Gasper, K., & Clore, G. L. (2002). Attending to the big picture: Mood and global versus local processing of visual information. *Psychological Science*, *13*, 34–40.

Glucksberg, S., Gildea, P., & Bookin, H. (1982). On understanding nonliteral speech: Can people ignore metaphors? *Journal of Verbal Learning and Verbal Behavior*, *21*, 85–98.

Green, B. G., Lederman, S. J., & Stevens, J. C. (1979). The effect of skin temperature on the perception of roughness. *Sensory Processes*, *3*, 327–333.

Griskevicius, V., Cialdini, R. B., & Kenrick, D. T. (2006). Peacocks, Picasso, and parental investment: The effects of romantic motives on creativity. *Journal of Personality and Social Psychology*, *91*, 63–76.

Hampton, J. A. (2002). Language's role in enabling abstract, logical thought. *Behavioral and Brain Science*, *25*, 688.

Harlow, H. F. (1959). Love in infant monkeys. *Scientific American*, *200*, 64–74.

Henderson, M.D., Trope, Y., & Carnevale, P. J. (2006). Negotiation from a near and distant time perspective. *Journal of Personality and Social Psychology*, *91*, 712–729.

Hong, J., & Sun, Y. (2012). Warm it up with love: The effect of physical coldness on liking of romance movies. *Journal of Consumer Research*, *39*, 293–306.

IJzerman, H., & Cohen, D. (2011). Grounding cultural syndromes: Body comportment and values in Honor and Dignity cultures. *European Journal of Social Psychology*, *41*, 456–467.

IJzerman, H., & Foroni, F. (2012). Not by thoughts alone: How language supersizes the cognitive toolkit. *Behavioral and Brain Sciences*, *35*, 226–227.

IJzerman, H., Karremans, J. C., Thomsen, L., & Schubert, T. W. (2013). Caring for sharing. *Social Psychology*, *44*, 160–166.

IJzerman, H., & Koole, S. L. (2011). From perceptual rags to metaphoric riches: Bodily, social, and cultural constraints on socio-cognitive metaphors. *Psychology Bulletin*, *137*, 355–361.

IJzerman, H., Regenberg, N. F. E., Saddlemyer, J., & Koole, S. L. (2013). Spelling out the science: Perceptual effects of linguistic category priming reconsidered among Dutch and Brazilian samples. Available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2304671

IJzerman, H., & Semin, G. R. (2009). The thermometer of social relations: Mapping social proximity on temperature. *Psychological Science*, *20*, 1214–1220.

IJzerman, H., & Semin, G. R. (2010). Temperature perceptions as a ground for social proximity. *Journal of Experimental Social Psychology*, *46*, 867–873.

Isen, A.M., & Daubman, K. A. (1984). The influence of affect on categorization. *Journal of Personality and Social Psychology*, *47*, 1206–1217.

Ji, L. -J., Peng, K., & Nisbett, R. E. (2000). Culture, control, and perception of relationships in the environment. *Journal of Personality and Social Psychology*, *78*, 943–955.

Kim, S. H., Vincent, L. C., & Goncalo, J. A. (2013). Outside advantage: Can social rejection fuel creative thought? *Journal of Experimental Psychology General*, *142*, 605–611.

Klein, O., Ventura, P., Fernandes, T., Garcia-Marques, L., Licata, L., & Semin, G. R. (2010). Effects of schooling and literacy on linguistic abstraction. *European Journal of Social Psychology*, *40*, 1095–1102.

Kolb, P., Gockel, C., & Werth, L. (2012). The effects of temperature on service employees' customer orientation: An experimental approach. *Ergonomics*, *55*, 621–635.

Kray, L. J., Galinsky, A.D., & Wong, E. M. (2006). Thinking within the box: The relational processing style elicited by counterfactual mind-sets. *Journal of Personality and Social Psychology*, *91*, 33–48.

Kuhl, J., & Kazen, M. (2008). Motivation, affect, and hemispheric asymmetry: Power versus affiliation. *Journal of Personality and Social Psychology*, *95*, 456–469.

Kühnen, U., Hannover, B., & Schubert, B. (2001). The semantic–procedural interface model of the self: The role of self-knowledge for context-dependent versus context-independent modes of thinking. *Journal of Personality and Social Psychology*, *80*, 397–409.

Kühnen, U., & Oyserman, D. (2002). Thinking about the self influences thinking in general: Cognitive consequences of salient self-concept. *Journal of Experimental Social Psychology*, *38*, 492–499.

Landau, M. J., Meier, B. P., & Keefer, L. A. (2010). A metaphor-enriched social cognition. *Psychological Bulletin*, *136*, 1045–1067.

Leung, A. K. -y, Kim, S., Polman, E., Ong, L. S., Qiu, L., Goncola, J., et al. (2012). Embodied metaphors and creative "acts". *Psychological Science*, *23*, 502–509.

Mandler, J. M. (1992). How to build a baby II: Conceptual Primitives. *Psychological Review*, *99*, 587–604.

Marsh, R. L., Ward, T. B., & Landau, J.D. (1999). Implicit learning expressed in a generative cognitive task. *Memory & Cognition*, *27*, 94–105.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, *81*, 922–934.

Mednick, M. T., Mednick, S. A., & Mednick, E. V. (1964). Incubation of creative performance and specific associative priming. *Journal of Abnormal and Social Psychology*, *69*, 84–88.

Rosch, E. (1975). Cognitive re-presentations of semantic categories. *Journal of Experimental Psychology General*, *104*, 192–233.

Sawyer, R. K. (2006). *Explaining creativity: The science of human innovation*. New York: Oxford University Press.

Schooler, J. W., & Melcher, J. (1995). The ineffability of insight. In S. M. Smith, T. B. Ward, & R. A. Finke (Eds.), *The creative cognition approach* (pp. 97–133). Cambridge, MA: MIT Press.

Shimmack, U. (2012). The ironic effect of significant results on the credibility of multiple-study articles. *Psychological Methods*, *17*, 551–566.

Simmons, J., Nelson, L., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allow presenting anything as significant. *Psychological Science*, *22*, 1359–1366.

Simonton, D. K. (2000). Creativity: Cognitive, developmental, personal, and social aspects. *American Psychologist*, *55*, 151–158.

Simonton, D. K. (2003). Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives. *Psychological Bulletin*, *129*, 475–494.

Sligte, D. J., De Dreu, C. K. W., & Nijstad, B.A. (2011). Power, stability of power, and creativity. *Journal of Experimental Social Psychology*, *47*, 891–897.

Smith, S. M., & Blankenship, S. E. (1991). Incubation and the persistence of fixation in problem solving. *American Journal Psychology*, *104*, 61–87.

Steinmetz, J., & Mussweiler, T. (2011). Breaking the ice: How physical warmth shapes social comparison consequences. *Journal of Experimental Social Psychology*, *47*, 1025–1028.

Stevens, J. C. (1982). Temperature can sharpen tactile acuity. *Perception & Psychophysics*, *31*, 577–580.

Subramaniam, K., Kounios, J., Parrish, T. B., & Jung-Beeman, M. (2008). A brain mechanism for facilitation of insight by positive affect. *Journal of Cognitive Neuroscience*, *21*, 415–432.

Szymkow, A., Chandler, J., IJzerman, H., Parzuchowski, M., & Wojciszke, B. (2013). Warmer hearts, warmer rooms. *Social Psychology*, *44*, 167–176.

Taft, R. (1971). Creativity: Hot and cold. *Journal of Personality*, *39*, 345–361.

Torrance, E. P. (1972). Can we teach children to think creatively? *Journal of Creative Behavior*, *6*, 114–143.

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review*, *117*, 440–463.

Williams, L. E., & Bargh, J. A. (2008). Experiencing physical warmth promotes interpersonal warmth. *Science*, *322*, 606–607.

Williams, K. D., Cheung, C. K. T., & Choi, W. (2000). Cyberostracism: Effects of being ignored over the internet. *Journal of Personality and Social Psychology*, *79*, 748–762.

Wuensch, K. L. (2012). Using SPSS to obtain a Confidence Interval for Cohen's d. Retrieved January 3, 2014 from http://core.ecu.edu/psyc/wuenschk/SPSS/CI-d-SPSS.pdf

Zabelina, D. L., & Robinson, M.D. (2010). Creativity as flexible cognitive control. *Psychology Aesthetics Creativity*, *4*, 136–143.

Zadro, L., Williams, K. D., & Richardson, R. (2004). How low can you go? Ostracism by a computer is sufficient to lower self-reported levels of belonging, control, self-esteem, and meaningful existence. *Journal of Experimental Social Psychology*, *40*, 560–567.

Zhong, C. B., & Leonardelli, G. J. (2008). Cold and lonely: Does social exclusion literally feel cold? *Psychological Science*, *19*, 838–842.

Zhou, X., Wildschut, T., Sedikides, C., Chen, X., & Vingerhoets, A. J. J. M. (2012). Heartwarming memories: Nostalgia maintains physiological comfort. *Emotion*, *12*, 678–684.