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Research report

Gustatory pleasure and pain. The offset of acute physical pain enhances responsiveness to taste ☆

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ABSTRACT

The idea that pain may serve to produce pleasurable states has been noted by theorists and, more recently, substantiated by empirical findings. We explored the possibility that, beyond producing positive hedonic states, the offset of pain may serve to enhance the capacity for gustatory pleasure. Across three studies we examined whether pain offset may enhance responsiveness to taste. In Study 1 participants enjoyed chocolate more after the experience of pain compared to completing a similar but non-painful task. In Study 2, pain offset increased the perceived intensity of a range of tastes, both pleasant and unpleasant, indicating that the effects of pain offset are not limited to the processing of positive hedonic stimuli. In Study 3, pain offset increased sensitivity to different flavors. The findings suggest that the offset of acute pain increases awareness of, and therefore sensitivity to, gustatory input, thereby enhancing the capacity for gustatory pleasure.

Introduction

Philosophers have often mused about the relationship between pain and pleasure. The romantic view of pain was that it provides depth to life and reveals true beauty (Morris, 1991). Others have argued that pain provides an important contrast for pleasure, and that the experience of pleasure is defined by the experience of pain (Verri, 1781; cited in Guidi (1994)). It is perhaps for this reason that people the world over enjoy the consumption of chili pepper (Rozin, 1990, 1999; Rozin & Schiller, 1980) or choose to engage in other painful activities such as intense exercise, ice-swimming, painful religious rituals, masochistic sexual practice, and even self-harm (Baumeister, 1988; Glucklich, 2001; Le Breton, 2000; Morris, 1991; Nock, 2010a, 2010b; O'Connor & Cook, 1999; Zenner, De Decker, & Clement, 1980).

Providing some insights into the links between pain and pleasure, research suggests that pain may be experienced as rewarding in some contexts (Becerra, Breiter, Wise, Gonzalez, & Borsook, 2001; Gear, Aley, & Levine, 1999; Leknes & Tracey, 2008; Zubieta et al., 2001), that experiences of pain may regulate negative affective states (Chapman, Gratz, & Brown, 2006; Claes, Klonsky, Muehlenkamp, Kuppens, & Vandereycken, 2010; Franklin et al., 2010) and may even produce positive affective states (Boecker et al., 2008; Franklin, Lee, Hanna, & Prinstein, 2013; Klonsky, 2009; Leknes, Brooks, Wiech, & Tracey, 2008). More broadly, it appears that people gain pleasure from all manner of innately negative experiences (Rozin, Guillot, Fincher, Rozin, & Tsukayama, 2013). Here we investigate another way in which the experience of pain may be rewarding; that in addition to producing positive hedonic states, pain offset may also change people's enjoyment of subsequent stimuli.

A number of studies have investigated how pain may change the value attached to subsequent stimuli. These conditioning studies have shown that pairing pain offset with neutral stimuli results in approach toward/liking of those stimuli (see e.g., Andreatta, Mühlberger, Yarali, Gerber, & Pauli, 2010; Smith & Buchanan, 1954; Tanimoto, Heisenberg, & Gerber, 2004; Zanna, Kiesler, & Pilkonis, 1970). These findings are consistent with research showing that pain offset may produce positive affective states (Franklin, Lee, et al., 2013; Franklin, Puzia, et al., 2013; Leknes et al., 2008). That is, the positive affective states produced by pain offset relief become associated with subsequent stimuli, thereby increasing liking for those stimuli. What has never been addressed, however, is how stimuli themselves may be processed close to the offset of pain. Specifically, we examine whether the offset of painful experiences may increase sensitivity to, and therefore enhance the capacity to enjoy, pleasant tastes.

One possibility is that positive affective states associated with pain offset not only become linked to gustatory input via associative learning, but also change how gustatory stimuli are processed. Research on pain's capacity to regulate affect suggests that pain commandeers neural regions associated with both pain and affect

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(Barrett & Bliss-Moreau, 2009; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012), allowing relief from pain to incidentally generate emotional relief (Franklin, Puzia, et al., 2013). Taste also activates neural regions overlapping with pain (see also Small & Apkarian, 2006), suggesting that pain relief may also incidentally affect how taste is processed, increasing the pleasantness of gustatory stimuli.

A related possibility is that pain activates the opioid system (Leknes & Tracey, 2008). Activation of this system has been shown to enhance the pleasantness of sweet tastes and decrease the aversiveness of bitter foods in rodents (Berridge, 2002; Doyle, Berridge, & Gosnell, 1993; Parker, Maier, Rennie, & Crebolder, 1992; Pecina & Berridge, 1995, 2000; Rideout & Parker, 1996). It has also been linked to the greater enjoyment of sexual behavior (Murphy, Checkley, Seckl, & Lightman, 1990). Moreover, the opioid system remains activated after the cessation of pain (Sprenger et al., 2006) and has been linked to positive affective states arising after pain has ceased (e.g., Boecker et al., 2008). This suggests that the neurobiological correlates of pain may serve to enhance enjoyment of subsequent stimuli, and specifically the enjoyment of pleasant tastes.

Both proceeding possibilities indicate that pain may shift the hedonic value of gustatory stimuli in a positive direction. Another possibility is that pain may increase sensitivity to both pleasant *and* unpleasant tastes. Pain is a primary threat signaling system that serves to indicate tissue damage and therefore recruits resources aimed at action and escape (Eccleston & Crombez, 1999; Legrain et al., 2009; Shackman et al., 2011). As such, physical pain is a powerful source of arousal (Garey et al., 2003; Pfaff, 2006; Price, 2000; Weil, Zhang, Hornung, Blizard, & Pfaff, 2010) that serves to capture attention and focus awareness on immediate sensory experience (Craig, 2002, 2003, 2009; Eccleston & Crombez, 1999). This evolved response serves to heighten awareness of the immediate sensory experience of pain. It may also, however, have implications for how other sensory experiences, occurring close to the offset of pain, are processed and responded to. We argue that the body remains in a vigilant state after pain, serving to maintain increased arousal and awareness of further physiological and environmental threat. During this state, awareness is generalized to focus on the physiological condition of the body, and this increases receptivity, and therefore sensitivity, to sensory experiences more broadly.

The possibility that pain may enhance sensory processing sensitivity is consistent with research demonstrating that arousal enhances responsiveness to goal-relevant or high-priority stimuli (Mather & Sutherland, 2011). For example, under conditions of high arousal participants are faster to respond to goal-relevant stimuli and are better able to direct attention to prioritized stimulus characteristics (Chajut & Algom, 2003; Cornsweet, 1969). This prediction is also consistent with the work on pain offset which shows that self-injurers who were exposed to pain (cold-pressor task) showed enhanced quality of information processing (Franklin et al., 2010).

We directly examined the possibility that pain may increase sensitvity to taste across three studies. In order to determine whether pain increases enjoyment of pleasant tastes, in Study 1 we asked people to rate their enjoyment of pleasant tasting stimuli (chocolate) after the experience of pain (vs. control). We also aimed to provide insight into possible pathways through which this increased enjoyment might occur. If enhanced gustatory pleasure is evident due to the positive affect arising from pain or activation of the opioid system, we would expect to see intensity ratings of pleasurable tastes increase, but intensity ratings of unpleasant tastes decrease. If enhanced pleasure is due to increased sensitivity to, and awareness of, the body's physiological state, then intensity ratings of both pleasant and unpleasant stimuli should increase. We tested these possibilities in Study 2. Finally, in Study 3, we directly investigated the possibility that pain increases awareness of, and therefore sensitivity to, subsequent stimuli by examining whether participants were more accurate in their sensory perception after pain.

Study 1 – Method

Thirty-six participants (28 women, $M_{age} = 23.69$, $SD = 4.97$) were drawn from an on-line research participation pool and paid $10. They were allocated to either a pain condition ($n = 19$) or a no-pain condition ($n = 17$). To induce pain we used a modified version of the cold-pressor task (see Bastian, Jetten, & Fasoli, 2011; Bastian, Jetten, & Stewart, 2013). Participants were required to insert their hand into a container filled with ice-water (0–2 °C). Inside there was another small container with a hole in it and a number of loose metal balls in the bottom. Participants were required to pick up the metal balls and place them in the container one at a time for as long as they could. In order to ensure that all participants had sufficient exposure to the painful stimulus, we asked those who withdrew their hand within a 1 min period to re-insert their hand when ready until one minute had passed. In the control condition participants completed the same task except in room temperature water (~20 °C) for 90 s. Tasks were designed to be equivalent in length, purpose, required compliance and sense of achievement.

All participants were then invited to participate in a separate 'consumer study'. They were asked to sample a chocolate biscuit and to rate the extent to which they enjoyed eating the biscuit and how pleasant they found the flavor to be. Ratings of pleasure and enjoyment were highly correlated ($r = .75$, $p < .001$) and thus were combined to form a measure of enjoyment. Participants completed the 20-item version of the positive and negative affect scale (PANAS: Watson, Clark, & Tellegen, 1988) both prior to the pain/no-pain induction and also at the end of the taste test. Participants also rated how painful their experience was on the Wong–Baker Pain Scale (Wong & Baker, 1988) (0 = *no hurt* to 5 = *hurts worst*). They were debriefed using a funnel debriefing procedure which involved a series of increasingly specific questions regarding the purpose of the study. No participant demonstrated any insight into the study's hypotheses.

Results and discussion

One participant left their hand submerged in the ice bath for an unusually long period of time (>7 min; more than 3 standard deviations above the mean). This participant was removed, leaving $n = 18$ in the pain condition. Participants in the pain condition kept their hand in the bath for an average of 98 s ($SD = 1.36$). A manipulation check revealed that participants in the pain condition rated the physical task as significantly more painful ($M = 2.69$, $SD = 1.10$) than those in the control condition ($M = 0.06$, $SD = .06$), $t(33) = 9.65$, $p < .001$. There were no differences in positive ($\alpha = .88$) or negative mood ($\alpha = .78$) at either Time 1 ($ts < 1.06$, $ps > .298$) or Time 2 ($ts < .79$, $ps > .436$). An ANOVA revealed a significant effect of condition on enjoyment, $F(1,33) = 6.26$, $p = .017$, $\eta^2 = .16$. Participants in the pain condition rated the chocolate biscuit as more enjoyable ($M = 6.03$, $SD = 0.85$) than participants in the no-pain condition ($M = 4.97$, $SD = 1.57$). This effect remained when separately controlling for gender, the amount of time taken when completing the physical task, and positive and negative affect after the taste test.

Providing direct support for our main research questions, the findings of Study 1 indicate that physical pain offset increases