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Do cheerfulness, exhilaration, and humor production moderate pain tolerance? A FACS study

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Abstract

Prior studies have shown that watching a funny film leads to an increase in pain tolerance. The present study aimed at separating three factors considered potentially essential (mood, behavior, and cognition related to humor), and examined whether they are responsible for this effect. Furthermore, the study examined whether trait cheerfulness and trait seriousness as measured by the State-Trait-Cheerfulness-Inventory (STCI; Ruch, Köhler, & van Thriel, 1996) moderate changes in pain tolerance. 56 female subjects were assigned randomly to three groups, each having a different task to pursue while watching a funny film: (1) get into a cheerful mood without smiling or laughing ("Cheerfulness"); (2) smile and laugh extensively ("Exhilaration"); and (3) produce a humorous commentary to the film ("Humor production"). Pain tolerance was measured using the cold pressor test before, immediately after, and 20 minutes after the film. Results indicated that pain tolerance increased for participants from before to after watching the funny film and remained high for the 20 minutes. This effect was moderated by facial but not verbal indicators of enjoyment of humor. Participants low in trait seriousness had an overall higher pain tolerance. Subjects with a high score in trait cheerfulness showed an increase in pain tolerance after producing humor while watching the film whereas subjects low in trait cheerfulness showed a similar increase after smiling and laughter during the film.

Introduction

Among the many putative positive effects of humor and laughter on physical and psychological well-being, the link with pain perception seems to be one of the most promising. As early as 1928, Walsh observed that laughter seemed to have analgesic effects on postoperative pain. By now there are several studies on the subject of humor, laughter, and pain (see reviews in McGhee, 1999; Martin, 2001), and the overall results seem to favor the existence of a link. However, many questions remain unanswered. In particular, we don't know what the underlying biological mechanisms are, when exactly the effect occurs (i.e., what aspects of humor and laughter are crucial), and what is the role of the sense of humor.

Proposed mechanisms. One important question relates to the means by which humor or laughter influence pain. One hypothesis is that laughter could reduce pain due to its relaxing effects (Fry, 1992; Smith, 1986). However, the supposed relaxing effects of laughter have not yet been demonstrated in physiological data (Ruch, 1993). Another hypothesis claims that laughter stimulates the production of endogenous opioids and thus leads to a reduction in pain. However, Berk et al. (1989) could not find any change in the level of beta-endorphins after showing a humorous video, but they only had a very low number of male subjects in their study. Likewise, the study by Itami, Nobori, and Teshima (1994) did not show any effect of laughter on beta-endorphins. A more cognitive influence of humor can also be found in O'Connell's (1976) suggestion that individuals with a high sense of humor are able to change their perceptual perspective quickly. This ability to change one's perspective could help to create a distance from the threatening aspects of pain. If one is able to laugh at pain it cannot be threatening at the same time (Ditlow, 1993). The created distance may also help to gain control of the situation and reduce negative emotions at the same time. Both of these are important aspects of psychological pain therapy (Weisenberg, 1994). Laughter can also be seen as an effective strategy of distraction (McCaffery, 1990; Trent, 1990), and if it takes place in social interaction it can be perceived as a form of social support (Francis et al., 1999). Laughing together can lead to the reduction of an external threat, creating a bond between the laughing individuals. The occurring closeness is perceived as social support. Both distraction and social support have a positive effect on reported clinical pain (Feldman, Downey, & Schaffer-Neitz, 1999; Weisenberg, 1994).

Empirical Evidence. The studies conducted so far on the influence of humor on pain were either experimental or clinical, used different pain induction procedures or patients suffering from chronic or acute pain, used different designs with different control groups, and often included "sense of humor" as a moderator variable. Each of these will be discussed separately.

Experiments have typically utilized one of three methods of inducing pain: the cold pressor test (CPT), transcutaneous end nerve stimulation (TENS), and ischemic pain induced by a blood-pressure cuff. The CPT, which has been used most often, requires participants to submerge their hand in ice-cold water. To test the effects of humor on pain, participants have typically been shown a humorous videotape or audiotape. To control for alternative explanations, the effects of the experimental groups have been compared with groups in which individuals watched either no film, or an emotionally arousing negative film, or an emotionally neutral documentary film. Measurements have typically been taken immediately before and after the humor intervention. However, the study by Weisenberg, Raz, and Hener (1998) suggests that the humor-induced changes endure and humor-specific effects can be found as late as 30 minutes after the end of the humor intervention. These findings have not yet been replicated, nor is the curve describing the diminishment of the effects known.

Overall, one can say that the humor interventions in past studies have been effective. Several experiments have shown that watching a funny film or listening to a funny audiotape leads to an increase in pain tolerance (for an overview see Martin, 2001; McGhee, 1999). The positive effect of the funny material was equivalent to that of relaxation and superior to active or passive distraction (Cogan, Cogan, Waltz, & McCue, 1987; Dale, Hudak, & DeGood, 1991).

Nevo, Keinan, and Teshimovsky-Arditi (1993) demonstrated, however, that a film must be perceived as funny in order to lead to an increase in pain tolerance. Other authors have also found that dramatic and sad films had a similar effect on pain tolerance (Weaver & Zillmann, 1994; Weisenberg, Tepper, & Schwarzwald, 1995; Zillmann, Rockwell, Schweitzer, & Sundar, 1993). In their other study, Weisenberg et al. (1998) found that a funny film was superior to a film inducing negative emotions if pain tolerance was measured 30 minutes after the film had been shown, even though there were no longer any differences in mood at that time. The authors' interpretation of these results was that humor and laughter may induce physiological changes, which affect the sensory components of pain. They argued that these changes take some time to develop and continue even after initial mood changes have dissipated.

Field studies have also been conducted with clinical patients. Two of these reported a decrease in pain after showing humorous material to patients. Unfortunately one of them (Yoshino, Fujimori, & Kohda, 1996) lacked a control group and the other did not report any statistical analyses (Adams & McGuire, 1986). In a more carefully conducted study, Rotton and Shats (1996) found that a group of patients who watched funny movies needed less minor analgesics after orthopedic surgery than did patients who watched non-humorous movies or no movies at all. This difference was not observed for major analgesics, however, and patients who watched funny movies without having a choice among several different movies actually showed a slightly higher level of usage of major analgesics. The authors concluded that watching funny movies can be aversive if these movies are inconsistent with one's humor preference.

Differential effects. Experimenters implicitly assume that their humor intervention is equally amusing to everybody. This obviously is not the case, as large interindividual differences exist in terms of both receptiveness to certain humor stimuli and the magnitude of the response. One can also expect that a small percentage of people will watch a funny film and just not find it amusing at all. If experimenters employ large groups those effects might be negligible, as effects average out and the power of the test is still strong due to the large sample size. However, for studies with a smaller sample size this heterogeneity can be problematic and may prevent finding results. For this reason, but also for the sake of illuminating the process, it is important to study moderator variables that are crucial for the emergence of differential effects. As mentioned above, Nevo et al. (1993) found perceived funniness to be crucial for the effect to emerge, and Rotton and Shats (1996) warned that funny movies can be aversive if they don't match one's taste.

Hence the amount of enjoyment induced might be a moderator variable. Humor research has not really agreed upon the nature of the emotion induced by humor, nor studied its components well. Emotion terms used have included mirth, amusement, hilarity, and exhilaration. In the present study, we use the latter term, based on its Latin root (hilaris = cheerful) to denote either the process of making cheerful or the temporary rising and fading out of a cheerful state (Ruch, 1993). More crucial than the term are ingredients and measurement. Humor research typically relies on assessing the perceived stimulus quality (i.e., funniness), not on the intensity of the induced affect (e.g., degree of amusement). In terms of the behavioral response to humor, smiling and laughter may be assessed, but care must be taken to distinguish genuine enjoyment from other forms of smiling and laughter (see articles in Ekman & Rosenberg, 1997), and there is still the problem of how to aggregate smiling and laughter into one response. Verbal ratings and behavioral data are typically only slightly correlated, leading to the question whether both subjective experience and overt behavior moderate the effects of humor on pain perception, and if so, whether or not they do so equally well.

A related question in research on humor and pain concerns which qualities of humor behavior and experience are responsible for the increase in pain tolerance found in the laboratory settings. So far, passive enjoyment has mainly been studied. However, it may be that active humor creation is better, as it involves more effort and hence might be, for example, more distracting. Likewise there is an unresolved question of intensity or complexity of the response. For example, do subjects have to actually laugh at the funny stimulus or is it sufficient if they get into a cheerful mood? As Martin (2001) points out, no study so far has examined the relation between overt laughter and changes in pain tolerance. Thus, it is important to see whether mere confrontation with a humor stimulus is sufficient or whether certain components (such as mood, emotion, or cognition) moderate the effect.

Sense of humor is another factor that might account for differential effects. It is more distal than intensity of enjoyment, and has to do with a disposition for enjoyment in several ways. Hence, not surprisingly, measures of sense of humor have been included in studies of pain. However, as theories of sense of humor are generally lacking, those instruments are most often used exploratively and without a clear rationale. Also, sense of humor is a multidimensional construct and hence this opens the question which component of sense of humor (if any) is related to what aspect of the moderation of effects of humor on pain perception.

In the model by Ruch and Köhler (1998), trait cheerfulness, seriousness and bad mood are seen as the temperamental basis of humor. Factor analytic studies have shown that those three traits account for much variance in sense of humor scales. In this model the humor temperaments could influence pain tolerance positively by several means. A high level of trait cheerfulness is related to a prevailing cheerful mood and a low threshold for laughter and smiling, which, in turn, could influence pain in the ways proposed above. Trait cheerful individuals might get into a cheerful mood more quickly and laugh more easily and hence benefit from the effects of presence of good mood and frequent laughter. Another facet of trait cheerfulness is a composed view of adverse life circumstances which is important for keeping a cheerful mood and being able to laugh even under adverse circumstances (Ruch & Köhler, 1998). Subjects high in trait cheerfulness also have a broad range of active elicitors of cheerfulness, smiling, and laughter, which increases the probability that they will find something to laugh about. They also show a generally cheerful interaction style that correlates with social closeness (Ruch & Köhler, 1998), leading to a higher level of social support. Hence one would expect that trait cheerfulness moderates the effects of the affective axis in humor on any positive outcome.

Trait seriousness goes along with the prevalence of serious states, the perception of even everyday events as important and considering them thoroughly and intensively, the tendency to plan ahead and set long-range goals, the tendency to prefer activities for which concrete, rational reasons can be produced, the preference for a sober object-oriented communication style, and a “humorless” attitude about cheerfulness-related matters (Ruch & Köhler, 1999). Individuals with low levels of trait seriousness may switch into a playful non bona fide mode of communication more easily (Raskin, 1998), they know more jokes and cartoons, remember humor better, are wittier, and produce more and funnier humor (Ruch & Köhler, 1998). Thus, individuals high in trait seriousness might demonstrate less interest in humor, even when it is presented in an experiment aimed at demonstrating the effects of humor on pain. Furthermore, a low level of trait seriousness could influence pain per se via the ability to perceive pain as not so important, being distracted more easily, and not considering things thoroughly or intensively, thereby influencing cognitive aspects of pain in a positive direction. A low level of trait seriousness thus could help one to get involved in or even produce humorous situations or behavior and enjoy the same, which in turn should increase the probability of influencing pain tolerance by one of the ways mentioned above.

Trait bad mood is basically composed of a generally bad mood, sadness and ill-humor, and sad or ill-humored behavior in cheerfulness-evoking situations (Ruch & Köhler, 1999). Thus a high level of trait bad mood increases the threshold for getting into a cheerful mood or for enjoying humor at all. One could expect a low level of trait bad mood to be necessary for easily inducing cheerfulness, smiling, and laughter, or even humor production, and using them to increase pain tolerance in one of the above-described ways.

Empirical evidence. So far there is little evidence that sense of humor (as measured by current self-report instruments) is related to pain measures. Several experiments (Mahoney et al., 2001; Weisenberg et al., 1995; Weisenberg et al., 1998, Zillmann et al., 1993) found no difference in pain tolerance between subjects with high or low levels in sense of humor. They either used a questionnaire inspired by the Coping Humor Scale (CHS) of Martin and Lefcourt (1983) or Ziv's Humor Questionnaire (Ziv, 1981). Nevo et al. (1993) reported a positive correlation only between the sub-component humor production of Ziv's Humor Questionnaire and pain tolerance. Hudak et al. (1991) used the Situational Humor Response Questionnaire (SHRQ; Martin &

Lefcourt, 1984), and found that subjects with a high sense of humor showed an increase in pain tolerance after watching a funny movie as well as after watching a documentary film, whereas subjects with a low sense of humor only showed an increase in pain tolerance after watching the funny film. In a field study, McMullen Leise (1993) even found a positive correlation between sense of humor as measured by the SHRQ and the CHS and the perceived usual pain of patients suffering from chronic rheumatoid arthritis. It is important to note, though, that all the measures used typically can be seen to combine a high degree of cheerfulness with a low degree of seriousness (Köhler & Ruch, 1996). Using unidimensional scales does not allow one to test affective and mental factors separately, or to look for subgroups (e.g., high cheerfulness combined with high seriousness).

The present study

The above review provides evidence that humorous material is capable of increasing pain tolerance in laboratory settings and possibly also in clinical settings if one refers to less severe levels of pain. The question of why and under what circumstances this effect emerges is yet unclear. In particular, we need to address what components of the humor response mediate this effect. Trait variables also need further investigation, as no convincing relation between sense of humor and pain tolerance has so far been found. Thus, it might be worthwhile also to include concepts like trait seriousness, which refer to the cognitive-communicative component of sense of humor that has not previously been explicitly studied.

The aim of the present experiment was threefold. First, we focused on variations of enjoyment of humor to study whether cheerfulness (as a mood), exhilaration (as affect) and humor production (as involving more cognitive elements in enjoyment) have different effects on pain tolerance. Those components were added to watching a funny movie and each was manifested in one of the three experimental groups utilized. Secondly, we studied whether degree of enjoyment moderates any effect. Both experiential and behavioral indicators of liking of humor were used, and for the latter various distinctions among types of smiles were drawn. Basically, only enjoyment displays (i.e., joint action of the zygomatic major and orbicularis oculi muscles) were expected to moderate the effects of humor on pain. Thirdly, we examined whether trait cheerfulness and seriousness moderate the effects of a humorous film on pain.

The exposure to a humor stimulus was a constant in the present experiment. No separate control groups were included to control for the effect of, for example, a non-humorous film, a film inducing negative emotions, or no instructions while watching the film. This was done in part due to limited resources, but also to be able to focus on the effects of different forms of the humor response, and this by nature requires a humor stimulus to be shown. This restriction in focus is not of great concern, as other studies (Cogan et al., 1987; Hudak et al., 1991; Weisenberg et al., 1998) have already demonstrated that a humorous film was superior to other films or no film at all, especially so for the delayed effects of a humor intervention (Weisenberg et al., 1998). Thus, all groups in this study watched the same humorous film, and, for all groups, the enjoyment induced was expected to lead to increased pain tolerance immediately after the film and continuing to the final pain perception measurement twenty minutes later. However, as participants of the three groups were given different instructions about how to react while watching the film, the effects of presence of cheerful mood (but no overt enjoyment) could be compared with the emotion of exhilaration (i.e., including also overt behavior, like smiling and laughter), and with humor production (i.e., enjoyment of film plus the cognitive shift into a playful mode). It was expected that the latter would yield the strongest effect, followed by the exhilaration and cheerful mood conditions in declining magnitude, respectively. Trait cheerfulness was expected to moderate the effects in all groups, while trait seriousness might only moderate the humor production condition. The amount of facial enjoyment was expected to predict the amount of change in pain perception.

Method

Research Participants

In total, 76 paid female subjects volunteered to participate in the study. Twenty subjects were excluded from the analysis as they either reported no pain during the CPT or did not fulfill the task they were given (e.g., did not inhibit laughter). No differences in age, education or other variables could be found for the excluded subjects. The remaining 56 subjects were between 20 and 41 years old (M=27.36, SD=5.7). They were randomly assigned to one of the three humor groups (cheerfulness n = 18, exhilaration n = 20, and humor production n = 18) and given the trait-version of the State-Trait-Cheerfulness-Inventory (STCI-T, Ruch et al., 1996) to assign them to groups of low and high Trait-Cheerfulness and low and high Trait-Seriousness via median split.

Pain and Humor Stimuli

Pain stimuli. The Cold Pressor test (CPT) was chosen as the pain stimulus as it has been used in other studies on the relation between humor and pain (e.g., Weisenberg et al., 1998), is easy to administer, and induces a sensation of pain that has been reported to be similar to clinical pain (Chapman et al., 1985). Before each trial, hand temperature was adjusted by asking participants to submerge their non-dominant hand in a container of warm water (37°C) for at least five minutes. The water for the cold pressor test was maintained at 0°C (+/- 0.5°C) and subjects were instructed to insert their non-dominant hand into the water up to their wrist. They were asked to say “Now” as soon as they felt a sensation of pain and “Stop” (and withdraw their hand from the water) as soon as they felt the pain was no longer tolerable. The time between the beginning of the immersion and the first pain sensation was taken as a measure of pain threshold, and the time that elapsed until subjects took their hand out of the ice-water was taken as a measure of pain tolerance. The difference (pain tolerance – pain threshold) was used as a measure of pain sensitivity (see, Wolff, 1982).

Humor stimulus and the three humor groups. A seven-minute segment of the film “Mr. Bean at the dentist” was used as a humorous stimulus. The film included sound effects but no speaking. Depending on which group participants were assigned to, they received different instructions on how to behave while watching the film.

The “cheerfulness” group was asked to enjoy the film and get into a cheerful mood but without smiling or laughing. Participants in the “exhilaration” group were instructed to smile and laugh extensively and to exaggerate their natural reactions of smiling and laughter in response to the film. Subjects assigned to the “humor production” group were told to give humorous verbal commentaries on the film and thereby produce humor themselves in addition to watching the film. The exact instructions can be found in the Appendix.

Instruments and Measurements

All participating subjects were asked for their age, educational status, handedness and if they suffered from chronic pain, or had taken any medication. Additionally, they were requested to fill in the following scales and instruments.

STCI. The aim of the State-Trait-Cheerfulness-Inventory (STCI) is to provide a reliable, valid, and economical assessment of the three constructs of cheerfulness, seriousness, and bad mood both as states (STCI-S) and traits (STCI-T). The standard trait form (STCI-T; Ruch et al., 1996) is a 60-item questionnaire in a 4-point answer format providing scores for the three traits of Cheerfulness (STCI-T CH), Seriousness (STCI-T SE), and Bad Mood (STCI-T BM). The standard state form (STCI-S; Ruch et al., 1997), containing 10 items per scale in a 4-point answer format (strongly disagree to strongly agree), is aimed at providing an assessment of state Cheerfulness (STCI-S CH), state Seriousness (STCI-S SE), and state Bad Mood (STCI-T BM) as well as the seven defining facets. This instrument has been validated in a variety of settings, including the study of the humor of teachers (Rissland, 2002), of depressed elderly (Hirsch, 2001), or the effects of nitrous oxide (see Ruch & Köhler 1998, for an overview).

Task and Film Rating Form. A rating sheet with seven questions was used to assess the participants' view of the film and their task while watching the film. They were asked to rate on a five-point scale how pleasant the task was to them, how successful they were in following the task, how interesting the task was for them, how well they were able to concentrate on the task, how far the task served as distraction concerning the next cold pressor test, and how funny the film was to them. Participants of the humor production group also indicated how funny they thought their commentary was. Subjects were also asked if they had seen the film beforehand and if they generally liked Mr. Bean as a comedy character.

Facial Measurement. A video camera was installed behind a one-way mirror in an adjacent room and measurements were taken via color videotapes, which provided a close-up, head-on view of the participant's face and shoulders. The Facial Action Coding System (FACS; Ekman, & Friesen, 1978) was used to code facial measurement. The FACS is an anatomically based, comprehensive, objective coding technique for measuring all observable facial movement. Frequency, intensity, and duration of action units (AUs) relevant for exhilaration (i.e., AU6, AU12) and the identification of non-enjoyment smiles were coded. Additionally, the occurrence of laughter (and humor production) was coded based on the audible reactions recorded with the help of a highly sensitive hidden microphone.

Frequency of exhilaration was defined by the total number of enjoyment displays in the form of smiling and laughter, identified as joint symmetric actions of zygomatic major (AU12; "lip corner puller") and the orbicularis oculi muscles (AU6; "cheek raiser"). Laughter was coded on a five-point scale from a single expulsion of air to a fully developed laughter pattern. A laugh was defined as an initial forced exhalation, followed by a more or less sustained sequence of repeated expirations of high frequency and low amplitude, which may or may not be phonated as "ha-ha-ha." Episodes of a single audible forced expiration occurring together with an AU12 formed the lower end of the intensity spectrum of events coded as laughter. Behavioral intensity of exhilaration was derived from the sum of all five intensity levels for vocal and facial data that occurred. Apart from genuine exhilaration, indicators for repressed and for faked smiling and laughter were also taken into account. Attempts at suppressing laughter were defined as those facial actions occurring together with (but typically starting after the onset of) AU12. Those were in particular AUs 8, 15, 17, 18, 23 and 24; those actions often were antagonistic movements to smiling (Keltner, 1997). Frequent attempts to deliberately enhance the intensity of the expression were louder vocalization (at a medium AU12 intensity), asymmetric AU12, wide mouth opening (AU26, or AU26), irregularity in timing and abrupt onset or prolonged offset, most often occurring without AU6 (i.e., the Duchenne marker). One participant had to be excluded from the analysis of facial data as the videotape did not record correctly.

Frequency of humor production was calculated by summing the number of comments given to the film that were in agreement with the instruction (i.e., attempts to be funny).

Procedure

The core of the experiment was a short period of time where participants watched a funny movie under one of three conditions, aimed at instilling and/or maximizing (a) cheerful mood, (b) overt expression of exhilaration, or (c) a humorous frame of mind. Measures of pain threshold and pain tolerance were taken much before (CPT-test), immediately before (CPT-pre), immediately after (CPT-post), and 20 minutes after (CPT-post 20) this segment of the experiment. Measures of temperament were taken and groups of highs and lows in a trait were determined a posteriori by median split on the scores.

General overview. When subjects entered the laboratory they were greeted by the female experimenter and told that this study was aimed at testing if the cold pressor test was a stable and valid instrument for studying pain perception. They were left blind to the real aim of the study and only instructed that there would be four pain measurements in total and three blocks with different tasks in between to bridge the time. They were also told that before each cold pressor test they would be asked to fill in a mood questionnaire to control possible influence of mood changes on pain perception and that the whole experiment would be filmed by a camera. Figure 1 gives an overview of the procedure.

Insert Figure 1 about here

Participants first received the STCI-S and were asked to hold their non-dominant hand in the container of warm water to adjust hand temperature while filling in the questionnaire. Then the test trial with the cold pressor test took place to ensure that participants understood the instructions for the cold pressor test correctly and to minimize fear in anticipation of a painful stimulus. After this first test trial, subjects were asked how they felt during the trial and instructed to tell the experimenter “now” and “stop” at similar sensations during the following trials. Next, the subjects filled in the STCI-T and another questionnaire not of interest here. They were told that personality could influence pain perception and thus we needed these questionnaires to control any possible influence. Following this the first measurement (CPT-Pre) took place (STCI-S and pain measurement with the cold pressor test). Next the experimenter secretly drew an envelope containing the assignment of the participants to one of the three experimental groups and read the behavioral instructions for the tasks while watching the humorous film. She left the room during the presentation of the Mr. Bean film and returned for the second measurement (CPT-Post: STCI-S and pain measurement). Next, participants filled in the Film Rating Form and they were then asked to wait until the last measurement would take place. Exactly 20 minutes after the end of the film the last pain measurement took place, with antecedent STCI-S and adjustment of hand temperature (CPT-Post-20).

When debriefed, they were paid DM 10 and were informed about the aim of the experiment. They were also informed about the videotaping and asked for permission to use the tapes. All subjects gave consent to have their tapes analyzed.

Results

Induction of the three humor conditions

A χ^2-Test with handedness, education, time of testing and chronic pain showed no differences between the three groups (cheerfulness, exhilaration, humor production). Forty-nine percent of the participants had previously seen the Mr. Bean film and 73% said they liked Mr. Bean in general. Funniness of the film was rated 3.64 on average ($sd = 1.08$) on a five-point scale. For these parameters no difference between the groups were found.

Manipulation check. State-cheerfulness (STCI-S CH) was elevated in all three groups after watching the film and returned to baseline level 20 minutes after the film. A repeated measures ANOVA with humor condition (cheerfulness, exhilaration, humor production) as a classification variable and testing time (before, after, and 20 minutes after the film) on the repeated measurement factor was performed for STCI-S CH, and showed a significant result for testing time ($F[2,56] = 44.901$, $p < .01$) but no differences between the experimental groups. Planned mean comparison revealed a significant increase from CPT-pre to CPT-post ($F[1,56] = 74.462$, $p < .01$) and a significant decrease from CPT-post to CPT-post-20 ($F[1,56] = 56.223$, $p < .01$). There was no significant difference between the level of state-cheerfulness comparing CPT-pre to CPT-post-20 ($F[1,56] = 1.279$, $p = .26$). Changes in the other STCI-S mood states were less pertinent. There were significant changes in state-seriousness ($F[2,56] = 21.971$, $p < .01$) and nearly significant changes for state-bad-mood ($F[2,56] = 3.040$, $p = .052$) with both decreasing in all groups after the film.

A one-way ANOVA with the three experimental conditions as a grouping factor and the frequency of AU12 combined with AU6 as dependent variable showed that genuine laughter and smiling occurred significantly more often in the exhilaration and humor production groups as compared to the cheerfulness group ($F[2,55] = 24.041$, $p < .01$). Facial attempts at controlling or repressing smiling and laughter were found mostly in the cheerfulness group ($F[2,55] = 5.608$, $p < .01$), whereas in the exhilaration group the highest number of facial indicators for not only natural but also arbitrarily forced or augmented laughter and smiling occurred ($F[2,55] = 7.085$, $p < .01$). Humor production only took place in the humor production group and participants showed a mean of 19.06 ($sd = 22.50$) humorous commentaries to the film.

One-way ANOVAs with the three humor conditions as a grouping factor on the questions of the Task and Film Rating Form revealed no differences between the groups for interest, concentration on the task, and distraction from the next cold pressor test ($F[2,52] = 1.132$, $p = .33$; $F[2,52] = 1.577$, $p = .22$; $F[2,52] = 1.366$, $p = .27$, respectively). However, differences among the groups were found for pleasantness ($F[2,52] = 3.461$, $p < .05$) and for successfulness ($F[2,52] = 4.729$, $p < .05$) with the exhilaration condition being judged as the most pleasant and the humor production condition being judged as the one that was least successfully achieved.

Overall the induction of cheerfulness, exhilaration, and humor production in the three experimental groups seemed to have worked as expected, with cheerfulness being increased in all three groups, smiling and laughter occurring mostly in the second and third group, and humor production only being shown in the third group. Thus, the three groups overall behaved differently in the desired ways.

Effects of humor condition on pain parameters

As the distribution of the pain parameters did not resemble normal distribution, cubic roots of all parameters were calculated and used for further analysis.

Pain threshold. An ANOVA for repeated measures, with humor condition (cheerfulness, exhilaration, humor production) as a grouping variable and testing time (before, after, and 20 minutes after the film) on the repeated measurement factor, showed a significant effect for testing time ($F[2,55] = 9.450$, $p < .01$). Planned mean comparisons showed that pain threshold increased in all three groups after the film ($F[1,56] = 16.074$, $p < .01$) and remained at a higher level than baseline 20 minutes after the film ($F[1,56] = 12.585$, $p < .01$). However, no differences between the three humor condition groups were found ($F[2,55] = 0.031$, $p = .97$). The interaction was not significant.

Pain tolerance. The analysis of the pain tolerance scores revealed similar results as found for pain threshold. There was a significant effect for repeated measurement ($F[2,56] = 7.629$, $p < .01$) but no significant difference between the three humor condition groups ($F[2,56] = 0.670$, ns). As revealed by planned mean comparisons, pain tolerance was augmented in all three groups after the film ($F[1,56] = 15.186$, $p < .01$) and stayed at a higher level 20 minutes after the film when compared to before the film ($F[1,56] = 4.757$, $p < .05$). The interaction was not significant.

Pain sensitivity. A similar repeated-measures ANOVA on pain sensitivity showed that the effect for testing time ($F[2,55] = 2.38$, $p = .09$) approached significance. Planned mean comparison showed that pain sensitivity increased from before to after the film ($p < .05$). The effect for condition and the interaction were not significant.

Does degree of enjoyment moderate the effects of exposure to humor on pain?

The previous analyses indicate that all three experimental groups had approximately the same increase in pain perception. Thus, while the additional instruction did not seem to have a differential effect, the mere exposure to the humor tape itself did have a beneficial effect on pain perception.

However, it is unlikely that the effects are merely due to the fact that participants saw a humorous video. It is more likely that the effects are moderated by enjoyment of the film. In other words, no or little effects can be expected for those who saw the film but did not enjoy it, whereas stronger effects should occur for those who enjoyed watching the tape. In short, amount of enjoyment may be the missing link triggering the changes in pain perception.

Two parameters of enjoyment were utilized to test this hypothesis. First, a composite index for subjective enjoyment of the tape was derived from those ratings that indicate a positive response to the tape and task (i.e., ratings of funniness of film and liking of Mr. Bean were summed). Secondly, among the many behavioral components of smiling and laughter the frequency of co-occurrence of AU12 and AU6 (i.e., the enjoyment display) was chosen. It underlies both smiling and laughter and is the best marker of happiness. The various distinctions among types of smiles were not considered in the ANOVA, but were included in subsequent correlational analyses. Subjective enjoyment and frequency of enjoyment display correlated significantly but modestly ($r = .35$, $p < .05$).

Subjective enjoyment. Funniness of film and liking of Mr. Bean correlated .60 ($p < .001$, df = 54) and were combined to form a score of subjective enjoyment. Based on a median split, groups of people low and high on subjective enjoyment were derived. Subsequently, 3x2 ANOVAs with humor condition (cheerfulness, exhilaration, humor production) and subjective enjoyment (low, high) as grouping factors and testing time (before, after, and 20 minutes after the film) on the repeated measures factor were computed for the different pain measures. None of the effects involving subjective experience reached significance (all ps > .10).

Facial enjoyment. Groups of participants low and high in facial enjoyment were formed based on frequency of AU6 and AU12 (median split within each experimental condition). The median of the first group was much lower, as participants were asked to suppress overt behavior. Still there was some variance, as some did smile or showed an enjoyment display with some sign of attempts to suppress the smile. Therefore, in this group the lows and highs are relative to each other. A series of 3x2 ANOVAs with humor condition (cheerfulness, exhilaration, humor production) and facial enjoyment (low, high) as grouping factors and testing time (before, after, and 20 minutes after the film) on the repeated measures factor were computed for the different pain measures.

The effect of facial enjoyment was significant on all three dependent variables. Individuals enjoying the film had higher pain threshold ($F[1, 49] = 7.084$, $p = .01$), tolerance ($F[1, 49] = 9.461$, $p < .01$), and sensitivity ($F[1, 49] = 8.039$, $p < .01$). Moreover, as expected, the interaction between facial enjoyment and testing time was significant for pain tolerance ($F[2, 98] = 6.378$, $p < .01$) and sensitivity ($F[2, 98] = 8.039$, $p < .001$), but not for pain threshold ($F[2, 98] = 0.283$, ns). Both interactions confirm that an increase in the pain measures was only found for those individuals showing overt facial enjoyment, while there was no change in those who did not show enjoyment displays. Figure 2 gives the results for pain tolerance for individuals low and high in facial enjoyment in each of the three experimental groups.

Insert Figure 2 about here

Figure 2 shows that the three groups of individuals that did not exhibit facial enjoyment in response to the video did not experience any change in pain tolerance. In contrast, the groups showing many enjoyment displays increased from pre to post and typically remained at a high level. Post hoc tests revealed that this was only the case for the exhilaration ($p < .01$) and humor production ($p < .05$) groups, while the effect for cheerful mood failed to reach significance ($p > .10$), suggesting that just feeling cheerful does not have the desired effect. The two groups (exhilaration and humor production) did not differ. Thus, the amount of enjoyment during the film increased pain tolerance and this change was sustained throughout the following 20-minute waiting period as well.

Interestingly, the difference between high and low facial enjoyment groups was already present at baseline (p <. 05). People who went on to enjoy humor more already showed higher pain tolerance before the film. In fact, pre measure and even test trial pain measures predicted later amount of facial enjoyment. Rank order coefficients between enjoyment and test trial measures of threshold ($r = .41$, p = 01), tolerance ($r = .56$, $p < .001$), and sensitivity ($r = .51$, $p < .01$) combined for the two groups were significant ($n = 37$).

For pain sensitivity the pattern of results was similar. Enjoyment displays increased scores from pre to post and post 20 (p <. 01 and $p < .05$, respectively) and for the non-enjoyment group there was even a significant decrease from pre to 20 minutes after the film ($p < .01$).

Is there any effect of enjoyment in the cheerfulness group? As there was no interaction between humor condition and testing time in the ANOVAs, one can assume that there is no difference among the three groups. However, the figures appear to show a less steep increase between pre and post for those who enjoyed the film in the cheerfulness condition. This might not be surprising, as to keep the groups (high vs. low enjoyment) about equal in size the cutoff point for number of displays was much lower in this group. Hence a separate analysis of the effects of enjoyment was undertaken for the cheerfulness group alone. These analyses revealed that, among those who showed relatively more enjoyment displays (compared to those who did not show enjoyment displays), there was indeed an increase in pain sensitivity ($p < .01$) but not in pain threshold or tolerance.

What exactly moderates the effects of exposure to humor on pain?

The results demonstrate that facial enjoyment is a powerful mediator between the presentation of a funny video and pain perception. The question arises as to what exactly are the parameters of the enjoyment display that cause this effect. Is it mere presence of enjoyment, or does it have to be enjoyment of a certain intensity level? Is laughter crucial or would smiling (of same intensity of AU12 and AU6) be sufficient? Do presence of negative emotions and performance of many voluntary actions play an impairing role?

In order to identify what variables mediate this effect, a number of possible intervening variables were examined in relation to the amount of tape-induced changes in pain perception. Changes in pain perception were computed by taking the difference between pain scores before the film and the ones after the film (CPT post – CPT pre). Spearman rank-order correlations were used, as neither the pain scores nor the differences were normally distributed. In the cheerfulness group participants were instructed to suppress the expression of smiling and laughter. Still there was some variance as some did smile or showed an enjoyment display with some sign of attempts to suppress the smile. Therefore, this group was analyzed separately and for exploratory purposes. The other two groups had a roughly equal frequency of enjoyment displays. In order to enhance the power of the test, the two groups with free expression of emotions were collapsed and the correlations were computed across them. To minimize the risk of type I error, only the correlations associated with hypotheses (e.g., the coefficients for genuine enjoyment) were tested for significance. The remaining correlations are given for descriptive purposes. The results are given in Table 1.

Insert Table 1 about here

Table 1 shows that it is primarily the joint action of the AU12 and AU6 occurring without any further action (e.g, other emotions, such as disgust) that predicted the pain perception scores. Single lip corner pulls (i.e., AU12), or lip corner pulls in any combination (even including laughter) did not yield correlations of comparable size. The sheer number of the combination of AU12 and AU6 also does not predict as well, as some of the joint actions might blend with concurrence of other emotions. In fact the presence of such “extra” facial actions correlated negatively with the increase in pain tolerance and sensitivity.

Insert Table 2 about here

Table 2 suggests surprising results inasmuch as it is not the loud laughter, or voiced laughter (glottis closed with vocal folds swinging) that predicts change in pain tolerance and sensitivity, but the unvoiced (glottis open) exhalations accompanying an AU12. There was laughter occurring without AU12 ($M = 1.38$, 0-8) but this was not correlated with pain perception at all.

Insert Table 3 about here

Table 3 shows that the intensity of smiles, rather than their frequency, is essential. The correlations for the more frequent low intensity levels of AU12 (i.e., levels 1, 2, and 3) have lower rank order correlations than the higher intensities (levels 4 and 5; both separated and combined). Duration of AU12 is predictive as well. In both tables it is especially pain tolerance and sensitivity that are well predicted.

Insert Table 4 about here

Finally, Table 4 shows that frequency of arbitrarily forced (but not dampened) exhilaration behavior and presence of negative emotions correlate negatively with pain tolerance and sensitivity. The more individuals were faking and not emotionally enhancing expressions, the less their pain tolerance increased. Likewise, if the film induced negative emotions, pain perception was negatively affected. However, frequency of voluntary actions and emergence of negative facial actions correlated positively with one another ($r = .43$, $p < .01$), and both correlated negatively with genuine enjoyment ($rs = -.39$ and $-.41$, respectively, $p < .05$). Thus, it is likely that the predictions overlap, and people with many enjoyment displays have fewer negative and contrived actions and also a gain in pain perception. Nevertheless, the direction of the correlations suggests clearly that additional voluntary efforts do not enhance but impair pain tolerance.

The frequency of enjoyment displays correlated well with prior cheerful mood ($r = .38$, $p < .05$), and cheerful mood (STCI-S) was in turn correlated with trait cheerfulness ($r = .59$, $p < .0001$). Thus, one can assume that averaged across many occasions trait cheerfulness will be linked with pain perception as it is a predictor of frequency of genuine enjoyment. However, whether this is the case for one situation, or whether there are even different types of effects as well will be examined next.

Does humorous temperament moderate the effects?

To test the role of personality in humor-induced changes in pain perception, groups of subjects with high (e.g., STCI-T CH+) and low (e.g., STCI-T CH-) trait scores were formed based on a median split in the respective STCI-T scale. Then, 3x2 ANOVAs with humor condition (cheerfulness, exhilaration, humor production) and personality (low, high) as grouping factors and testing time (before, after, and 20 minutes after the film) on the repeated measurement factor were computed for the various mood and pain measures. While hypotheses related primarily for trait cheerfulness and seriousness, an ANOVA for bad mood was included for exploratory purposes.

Trait Cheerfulness. The analysis for state-cheerfulness as dependent variable showed the expected significant main effect for trait cheerfulness with the subjects high in this trait being in an overall more cheerful state ($F[1,56] = 13.837$, $p < .01$). However, no significant interaction effects for trait cheerfulness were found. Thus, trait cheerful individuals were found to be in a more cheerful mood in all three experimental groups and at all measurement times. Likewise, the analyses for behavioral indicators for exhilaration and for humor production as dependent variables indicated no significant main or interaction effect for trait cheerfulness.

While there was no main or interactive effect of trait cheerfulness on pain threshold, for pain tolerance the three-way interaction was significant ($F[4,56] = 3.077$, $p < .05$). Inspection of the means (see Figure 3) shows that the effect was due to two groups (low trait cheerful people in the exhilaration condition, and high trait cheerful individuals in the humor production condition) whose pain tolerance increased significantly after the film and stayed at a high level also 20 minutes after the film.

Insert Figure 3 about here

Trait Seriousness. The three-way ANOVA showed a significant main effect for trait seriousness on state-cheerfulness with the subjects high in trait seriousness being in an overall less cheerful state ($F[1,56] = 4.100$, $p < .05$). No significant interaction effects for trait seriousness were found. For the indicators for exhilaration as dependent variables, no main effect for trait seriousness was found. However, there was a significant interaction between trait seriousness and humor condition for genuine enjoyment displays, i.e., smiling and laughter ($F[2,55] = 4.301$, $p < .05$). Participants low in trait seriousness showed less smiling and laughter than subjects high in trait seriousness in the cheerfulness group, but more in the exhilaration and humor production groups. No differences in amount of humor production were found when comparing subjects with high versus low trait seriousness.

The analysis of the pain measures showed significant main effects for trait seriousness on pain threshold ($F[1,56] = 5.405$, $p < .05$) and pain tolerance ($F[1,56] = 4.570$, $p < .05$). Subjects low in trait seriousness had higher pain thresholds and pain tolerance than did subjects high in trait seriousness. No interaction effects were found, however.

Insert Figure 4 about here

Trait bad mood. Variance analysis of pain parameters with subjects divided into groups of high and low trait bad mood via median split revealed no significant main or interaction effects for trait bad mood, except for pain tolerance, where a significant interaction of trait bad mood and humor group could be found ($F[2,56] = 4.114$, $p < .05$).

Interaction between Trait Cheerfulness and Trait Seriousness. To determine whether there were any interaction effects of trait cheerfulness and trait seriousness, participants were divided via median split into groups of high trait cheerfulness and high trait seriousness (CH+SE+), high trait cheerfulness and low trait seriousness (CH+SE-), low trait cheerfulness and high trait seriousness (CH-SE+), and low trait cheerfulness and low trait seriousness (CH-SE-). As the number of subjects in each group became rather small, the three humor condition groups were looked at separately for pain tolerance and results are only descriptive.

In the exhilaration group, only those subjects low in trait cheerfulness and low in trait seriousness showed an increase in pain tolerance after the film (see Figure 5) and could thus probably also have been the ones responsible for the increase in pain tolerance seen for the whole group of subjects low in trait cheerfulness in the exhilaration group. That is, it is the low serious/playful cheerful types who profited from the instructions that were aimed at generating a humorous mind.

Insert Figure 5 about here

In the humor production group, it was the subgroup of subjects high in trait cheerfulness and low in trait seriousness that seemed to profit most with respect to pain tolerance (see Figure 6), and these could also probably have been the group responsible for the increase seen in the whole group of subjects high in trait cheerfulness.

Insert Figure 6 about here

Discussion

Average pain threshold and pain tolerance increased in all three humor groups after the film and remained at an increased level 20 minutes after the film. This replicates the findings of Weisenberg et al. (1998), and indicates that the exposure to humor might have more lasting effects than hitherto thought. Most studies of physiological effects of humor have looked for more immediate effects but not distal ones. In both the Weisenberg et al. (1998) and the present study, the interval chosen was not long enough to determine when the induced effects disappear and pain tolerance returns to baseline. It should be noted that, at the 20-minute post-test, the mood states had already returned to baseline levels even though the physiological pain tolerance effects still prevailed.

Most importantly, the present study shows that genuine enjoyment expressed facially is a mediator between perceiving a humorous film and changes in pain perception. It is the facial configuration named (Ekman et al., 1990) the Duchenne display (to honor Duchenne who first described how this pattern distinguished enjoyment smiles from other kinds of smiling) that seems to be crucial for the pain effect to occur. The Duchenne display refers to the joint contraction of the zygomatic major and orbicularis oculi muscles (pulling the lip corners backwards and upwards and raising the cheeks causing eye wrinkles, respectively). Interestingly, the presence of laughter did not enhance the effect. Occurrences of negative emotions and of voluntary efforts to show or amplify joy were actually negatively associated. Thus, ideally, for a pain tolerance effect to occur, individuals should enjoy themselves in an unrestrained manner, not blending enjoyment with any other emotions, and they should not be forced to laugh. As regards the latter, we do not know what happens when initially forced laughter turns into genuine emotional laughter. At present, we only know that it is the enjoyment display in high frequency, intensity, and duration that yields this effect, whereas merely verbal signs of enjoyment do not. This is not meant to imply that subjective enjoyment per se cannot be used to predict pain tolerance, or is dissociated with facial expression, as subjective ratings and facial expressions of enjoyment were significantly but modestly correlated. However, as a single point measure (taken in retrospect), a subjective enjoyment rating may not adequately capture the affective events, whereas the continuously recorded facial actions do, and thus the latter are better predictors.

In a recent article (published after the present study was conducted) Martin (2001, p. 515) states that

> …[m]uch of the research to date, using experimental laboratory procedures with exposure to comedy videotapes, has either implicitly or explicitly focused on the hypothesis that health benefits result from physiological changes accompanying laughter. However, most of these studies have failed to monitor the actual occurrence of laughter, to distinguish various types of laughter, or to examine the relation between duration, frequency, or intensity of laughter and physiological outcomes. Thus, it may be that genuine physiological effects of particular types or degrees of laughter have gone largely undetected in the research due to sloppy methodological procedures, resulting in the weak and inconsistent pattern of results with which we are now faced. …

> Frequencies of each type of laughter can then be correlated with the dependent variables to determine whether possible health effects are limited to genuine spontaneous laughter or occur also with feigned or forced laughter. Besides distinguishing genuine and faked laughter, researchers should also address questions of how much laughter, of what intensity, for how long is needed to produce various physiological effects. This could be done by varying the funniness and duration of stimuli and by manipulating participants' laughter via instructions to laugh as much as possible versus suppressing laughter.

We did not distinguish between qualitatively different types of laughs (different for quality of affect), but the results do seem to suggest that the vocal act of laughter is not actually necessary, or at least not a better predictor than the enjoyment display per se. Indeed, we found that lower intensities of laughter (single or repeated audible expulsions of air) were more predictive than laughter associated with phonated ("ha-ha") sounds. Thus, genuine enjoyment at the level of a big smile seems to be optimal. However, one should not over-interpret the findings as they need to be replicated first. Also, it might be good to study a larger sample and examine different elements of laughter (facial, gestural, postural) as possible predictors. As the biochemistry and physiology of enjoyment is not clear yet, we must hold back speculations about the intervening variables between humor enjoyment and changes in pain perception. The present study adds three observations to this controversy. First, whatever is induced at the physiological or mental level prevails for at least half an hour. Secondly, it seems that, for the effects to occur, genuine enjoyment at the level of smiling is sufficient.

Third, laughter (at least in the form occurring in the present study) does not seem to enhance the effects but may even reduce them.

This study presents an anomaly compared to previous studies, however. Negative emotion-inducing videotapes have been found to produce increases in pain tolerance in previous studies, whereas negative emotion displays were negatively associated with pain tolerance changes in the present study. There is no ready answer for this except that the context might be important. Emergence of negative displays in a positive film might be counterproductive, interrupting the viewer's immersion into the film, while they might be appropriate in a negative emotion film

The present study also raises the question of the direction of causality. High versus low enjoyment was not varied experimentally so the interpretation that "enjoyment led to higher pain tolerance" is not the only possible one. Could it be that greater pain tolerance somehow leads to greater enjoyment of humor, as shown in facial expressions (especially since the difference was already present at pretest, even before humor stimuli were presented)? Or maybe there is a third variable, perhaps having to do with temperament at a physiological level, that influences both pain tolerance and cheerfulness/amusement. We need further studies to answer this question.

However, when individual differences were not taken into account, the three humor groups did not produce differences in changes in pain sensitivity or pain tolerance. The lack of significant interactions suggested that overall the three adjuncts to the exposure to humor worked equally well. As no group without special instruction was utilized, we do not know how the three conditions would compare with such a control group. However, within the groups, the presence of voluntary effort correlated negatively and in the cheerfulness condition the suppression of overt behavior generally lowered the effects.

Prior studies of the involvement of sense of humor in moderation of pain yielded meager or at best inconsistent findings. In the present study, trait cheerfulness and trait seriousness were involved in the moderation of the effects of humor on the pain parameters, but the effects were rather complicated. Subjects with a low level of trait cheerfulness had increased levels of pain tolerance right after and 20 minutes after the film in the exhilaration group, whereas subjects with a high level of trait cheerfulness showed increased levels of pain tolerance both right after and 20 minutes after the film in the humor production group. It was these two subgroups that also seemed to be responsible for the overall increase in pain tolerance right after and 20 minutes after the film when looking at all three groups together. Subjects with a low level of trait seriousness had an overall higher level of pain threshold and pain tolerance, and, when looking at the combination of trait cheerfulness and trait seriousness, it also seemed to be the subjects with low trait seriousness that probably were responsible for the effects found for trait cheerfulness. How can this be explained? Whereas both a high level of trait cheerfulness and a low level of trait seriousness went along with a higher level of state cheerfulness, subjects low in trait seriousness showed more genuine smiling and laughter in the exhilaration and humor production groups. As genuine smiling and laughter, but not state cheerfulness, were positively related to pain threshold and pain tolerance after the film and pain tolerance 20 minutes after the film, it was probably the fact that subjects low in trait seriousness smiled and laughed more that led to the increase in pain tolerance in those two groups.

The main effect found for trait seriousness with higher levels of pain tolerance on average over all three groups and all three measurement times could possibly be due to the fact that individuals with low levels of trait seriousness did not consider the pain stimulus as important, and this may have influenced the cognitive aspects of pain judgment in a positive way. The finding that subjects low in trait cheerfulness showed an increase in pain tolerance only in the exhilaration group, whereas subjects with high levels of trait cheerfulness showed a similar increase only in the humor production group, are not easily interpreted. The task of producing funny comments while watching the film might have been too difficult for subjects low in trait cheerfulness, but why did subjects high in trait cheerfulness not profit from the exhilaration task? To examine this, further experimental studies with more subjects and different control groups are necessary. If one considers genuine smiling and laughter to be responsible for physiological changes that lead to changes in pain perception, individuals with high levels of trait cheerfulness who laugh a lot more in their everyday life might be more used to laughing and thus not experience the physiological changes as strongly as individuals with low levels of trait cheerfulness. If the Opponent-Process Theory (Solomon, 1980) also works for the physiological changes induced by laughter and smiling, this could be the case.

Trait cheerfulness and seriousness should be related to pain perception also in a more direct way. There is ample evidence from this and related studies (e.g., Ruch, 1997; Ruch et al., 1997) that trait cheerfulness is a predictor of state cheerfulness and frequent enjoyment displays. Also, state cheerfulness represents an altered state conducive to smiling and laughter (Ruch, 1997). As enjoyment displays mediate the effects of humor on pain perception, one can assume that those effects accumulate and over long time spans individuals high in trait cheerfulness would be better off. In the present experiment no direct effect of trait cheerfulness on enjoyment display were found; however, this might be due to the fact that pain perception was a single occasion measure, and aggregation across several periods of humor consumption and pain measures may yield stronger relationships. Thus, while the interaction effects of cheerfulness and seriousness first need replication to be considered substantial, the direct effects of both on pain need to be demonstrated across aggregated occasions, or can be assumed to exist, as the relationships between intermediate links are well established. However, for single measurements there seems to be an imbalance in level of aggregation (one score in one experimental setting vs. aggregated statements about one's temperament).

The results of this study correspond in certain ways with previously published experimental studies on the relation between humor and pain and showed an increase in pain tolerance after subjects watched a funny film. The results of this study point out, though, that it could be specific subgroups of individuals that are responsible for these results, and that genuine smiling and laughter are necessary to change pain tolerance. The personality trait of low seriousness seems to go along with increased levels of pain tolerance, and thus should be considered further in studies on humor and pain and also when humor is used in clinical settings. Trait seriousness (or playfulness) is linked with processing and appreciation of types of humor and not so much with the affective response (Ruch & Köhler, 1998). Whereas cheerfulness as a personality trait might give clues to whether appreciation of humor in the form of smiling and laughter or active humor production are more useful to influence pain, trait seriousness could probably indicate whether any kind of humor intervention might work at all in order to change pain perception. For individuals low in seriousness, nonsensical humor would work best, whereas for individuals intermediate on this dimension more structured forms of humor might apply (Raskin, 1998).

Gross and Levenson (1997) found that the repression of positive emotion led to a decrease of reported amusement during a funny film and to increased sympathetic activity of the cardiovascular system. Even though in our study state cheerfulness was augmented after the film in all three groups and no differences in state cheerfulness after the film were found between the groups, differences in cardiovascular activity might have been present.

In sum, given the prior findings on humor and pain perception and the results of the present study, we can state with some confidence that this phenomenon of humor-induced pain tolerance is real. Future studies should now be aimed at illuminating the underlying mechanisms in more detail. However, care should be taken for a differentiated assessment of smiling and laughter, and the design should allow for the main surprising finding of the present study, namely that it is an intermediate degree of exhilaration or enjoyment (i.e., higher levels of intensity of enjoyment display, but no pronounced laughter) that seems to be most effective. Thus, it may not be true that “the more you laugh the better,” but rather that genuine enjoyment at an intermediate level is best. However, admittedly, very high levels of laughter were not involved in the present study.

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Appendix

Instructions used in the three experimental groups.

"Cheerfulness" group: You will now see a funny film. Please watch the film and try to get into the cheerful mood of the film, but without smiling or laughing while watching the film. It is very important that you do not laugh or smile and we will also control this via the videotape. Nevertheless you should try to have fun with the film and get into a cheerful mood. To sum up, it is important to feel cheerful but without laughing or smiling as you do so. Do you have any questions?

"Exhilaration" group: You will now see a funny film. Please watch the film and try to laugh extensively while doing so. When you would normally smile to yourself inwardly, you should now smile, and when you would normally smile you should laugh out loud now. It can be a little bit exaggerated, that is okay, as long as you laugh a lot and loud. It is not important to laugh all the time, only when you find something is funny, you should laugh stronger than usual. Do you have any questions?

"Humor production" group: You will now see a funny film. Please watch the film and try to give funny comments to the film loudly. It does not matter whether other people would find these comments funny, only that they are funny to you. There will of course be parts during the film where you cannot think of anything funny. That does not matter as there are parts in the film that are more suitable for funny comments and others that are not so suitable. Do you have any questions?

Figure Headings

<u>Figure 1</u>. Schematic overview of the experiment

<u>Figure 2</u>. Changes in pain tolerance as a function of experimental group and facial enjoyment (FE- = few enjoyment displays, FE+ = many enjoyment displays)

<u>Figure 3</u>. Changes in pain tolerance for individuals high (CH+) and low (CH-) in trait cheerfulness in the three experimental groups

<u>Figure 4</u>. Changes in pain tolerance for individuals high (SE+) and low (SE-) in trait seriousness in the three experimental groups

<u>Figure 5</u>. Changes in pain tolerance for individuals high (+) and low (-) in trait cheerfulness (CH) and seriousness (SE) in the exhilaration group

<u>Figure 6</u>. Changes in pain tolerance for individuals high (+) and low (-) in trait cheerfulness (CH) and seriousness (SE) in the humor production group

Table 1. Correlations between changes in pain perception (CPT post – CPT pre) and different facial and vocal actions

	AU12			AU12 + AU6		
	sole (n = 0-9)	all (8-49)	+ laughs (4-37)	all (8-47)	genuine (4-44)	blends (0-27)
Threshold	.10	.29#	.27#	.31#	.37*	-.04
Tolerance	.05	.31#	.27#	.39*	.66***	-.40*
Sensitivity	.05	.21	.13	.26	.58***	-.43**

Note. #p < .10, *p < .05, ** p < .01, *** p < .001.

AU12, AU6 = actions of zygomatic major and orbicularis oculi muscles, respectively; sole AU12 = AU12 not accompanied by AU6, all = all actions of a kind (AU12, or AU12+AU6) occurring (single or in any combination); laughs = index of laughter based on respiration and vocalization; blends = AU12+AU6 occurring with other actions, genuine = AU12+AU6 without further action.

Table 2. Correlations between amount of change in pain perception and types of laughter accompanying AU12

	Coded levels of type/intensity of laughter						
	SEx 3.84 (0-13)	REx 2.22 (0-19)	all Ex 6.05 (0-22)	SVo 3.62 (0-16)	RVo 6.62 (0-23)	RLVo 0.81 (0-4)	all RVo 4.19 (0-12)
Threshold	.22	.27	.29#	.15	.08	-.02	.05
Tolerance	.30#	.38#	.41*	.01	.16	.08	.14
Sensitivity	.31#	.29#	.43**	-.13	.07	.22	.10

Note. #$p < .10$, *$p < .05$, ** $p < .01$

SEx = single exhalation (“h”, “ch”), Rex = repeated exhalations (“ch-ch”), all EX = all exhalations (unvoiced laughter), SVo = single vocalization (e.g., “ha”), RVo = repeated vocalizations, RLVo = repeated loud vocalizations, all co-occurring with an AU12.

Table 3. Correlations between amount of change in pain perception and duration and frequency of the five intensity levels of AU12

	Coded levels of intensity (AU12)						Duration
	IL1	IL2	IL3	IL4	IL5	IL4&5	of AU12
	5.51	10.81	7.43	3.00	1.19	4.19	4.19
	(0-12)	(2-28)	(1-20)	(0-8)	(0-6)	(0-12)	(0-12)
Threshold	-.20	.22	.32*	.32*	.26	.30#	.27
Tolerance	-.13	.24	.25	.47**	.42***	.54**	.49**
Sensitivity	-.17	.15	.16	.42*	.39*	.49**	.44**

Note. #p < .10, *p < .05, **p < .01.

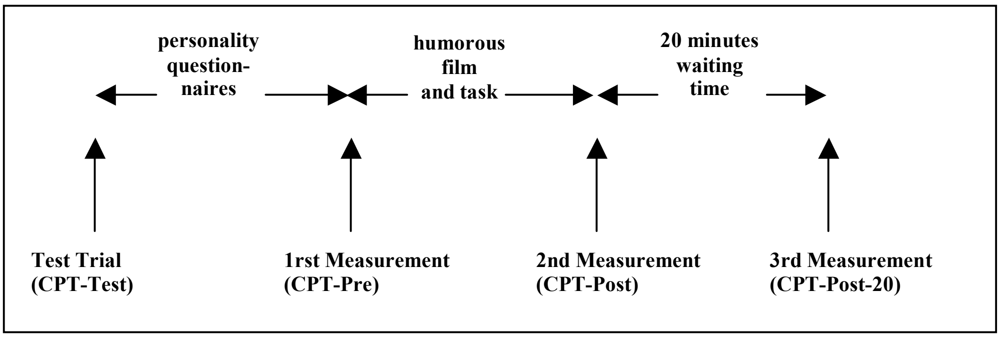
IL = Intensity levels of AU12.

Table 4. Correlations between frequency of negative and of voluntary facial actions and changes in pain perception

	voluntary M = 3.74 (0-22)	negative M = 1.30 (0-6)	dampening M = 1.22 (0-11)
Threshold	-.17	-.11	.20
Tolerance	-.48**	-.37*	.04
Sensitivity	-.50**	-.42*	.03

Note. *$p < .05$, **$p < .01$.

Voluntary = frequency of voluntary movements (e.g., loud vocalization or wide mouth opening not in proportion to low levels of AU12, voluntary facial actions); negative = frequency of negative emotions. Dampening = frequency of actions aimed at repressing and dampening the expression (AU15, AU8, AU17, AU18, AU23, AU24) occurring together with an AU12.


personality
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Test Trial
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1rst Measurement
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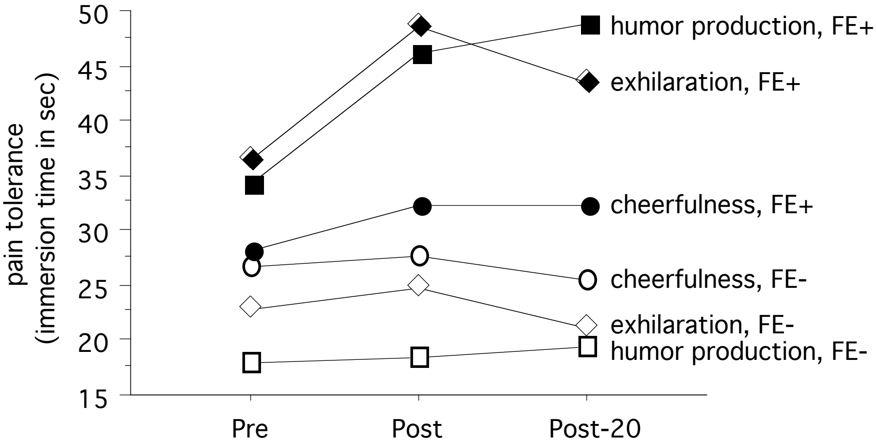
2nd Measurement
(CPT-Post)
3rd Measurement
(CPT-Post-20)

(Figure 1)


50
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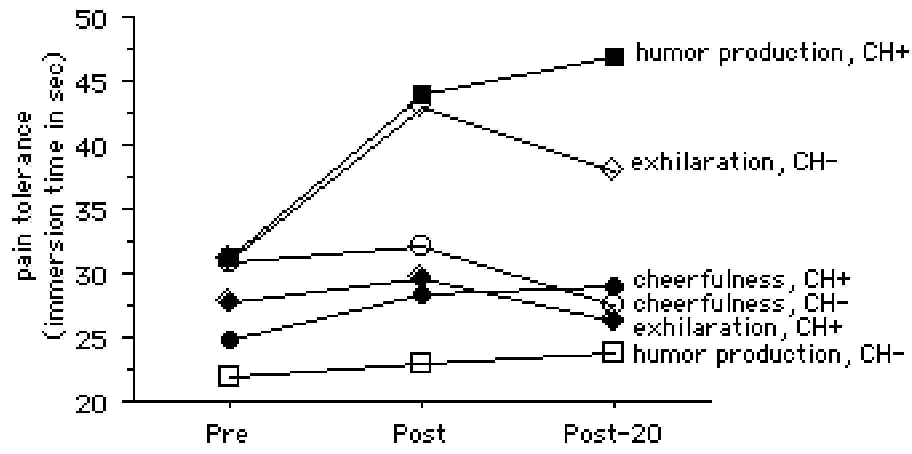
15
pain tolerance
(immersion time in sec)
Pre
Post
Post-20
humor production, FE+
exhilaration, FE+
cheerfulness, FE+
cheerfulness, FE-
exhilaration, FE-
humor production, FE-

(Fig 2)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pain tolerance
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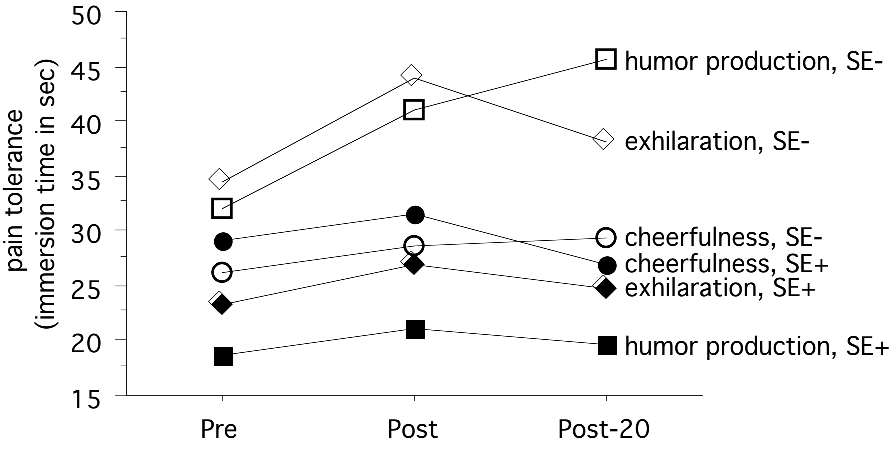
humor production, CH+
exhilaration, CH-
cheerfulness, CH+
cheerfulness, CH-
exhilaration, CH+
humor production, CH-
Pre
Post
Post-20

(Fig.3)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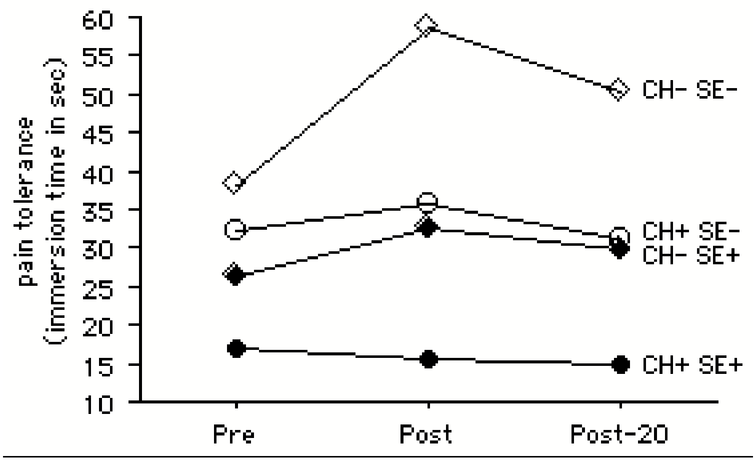
pain tolerance
(immersion time in sec)
Pre
Post
Post-20
humor production, SE-
exhilaration, SE-
cheerfulness, SE-
cheerfulness, SE+
exhilaration, SE+
humor production, SE+

(Fig 4)


pain tolerance
(immersion time in sec)
60
55
50
45
40
35
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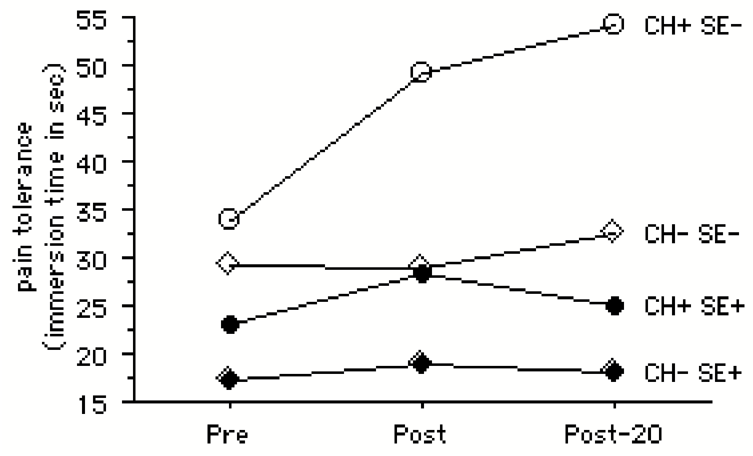
25
20
15
10
Pre
Post
Post-20
CH- SE-
CH+ SE-
CH- SE+
CH+ SE+

(Fig 5)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20
15
pain tolerance
(immersion time in sec)
CH+ SE-
CH- SE-
CH+ SE+
CH- SE+
Pre
Post
Post-20

(Fig 6)