International Journal of Psychophysiology 79 (2011) 211–218

Contents lists available at ScienceDirect

International Journal of Psychophysiology

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

Coherent with laughter: Subjective experience, behavior, and physiological responses during amusement and joy

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ARTICLE INFO

Article history:
Received 4 February 2010
Received in revised form 15 July 2010
Accepted 19 October 2010
Available online 27 October 2010

Keywords:
Positive emotion
Amusement
Joy
Laughter
Cardiovascular
Respiration
Coherence

ABSTRACT

Emotion research historically has adopted a fairly homogeneous view of positive emotions. The aim of the current study was to explore how two positive emotions, amusement and joy, differ in subjective, behavioral, cardiovascular, and respiratory characteristics. Thirty-nine participants viewed two film clips, each selected to elicit amusement or joy. As predicted, participants reported more amusement, showed more positive facial expressions and laughter, and exhibited less heart rate deceleration and a larger increase in respiratory amplitude in response to the amusement clip than in response to the joy clip. In addition, subjective, behavioral, and physiological indicators were more closely related in amusement than joy, which was largely attributable to laughter during amusement. The current study adds to a growing literature suggesting the importance of adopting a more nuanced conceptualization of positive emotion.

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1. Introduction

Emotion researchers historically have studied one positive emotion — usually referred to as happiness — and several negative emotions (Ekman, 1992; Schwartz et al., 1981; Stemmler, 1989; Werner et al., 2007). Recently, however, efforts have been made to better understand the potentially unique contributions of different positive emotional states (Argyle, 2001; Avia, 1997; Edwards and Cooper, 1988; Fredrickson, 2000; Keltner and Shiota, 2003; Sauter and Scott, 2007). As noted by Shiota et al. (2004), different positive emotions serve different functions in relationship development and maintenance, depending on the type and stage of relationship. For example, a potential romantic partner's display of joy may provide important information about his or her sociability, and hence desirability. Shared amusement may facilitate the establishment of values and norms among members of a social or ethno-cultural group (Zilberg, 1995) and laughter displays can serve as both incentive and reward for behavior (Provine, 2000). Thus, if positive emotions are not isomorphic in function, it is reasonable to expect that they would differ in their experiential, behavioral, and physiological components. In particular, positive emotions associated with laughter (e.g., amusement) may have a different architecture and serve unique interpersonal and physiological functions. The current study compares self-report, behavioral, cardiovascular, and respiratory responses, along with the interplay among these components (i.e., coherence; Ekman, 1992), in amusement and joy.

Identifying the behavioral and physiological characteristics of different positive emotions is made challenging by inconsistent terminology in the current literature. For example, humorous stimuli (e.g., comedy film clips) have been used to elicit emotional states described as "joy" (Britton et al., 2006; Hubert and de Jong-Meyer, 1991; Johnson and Fredrickson, 2005), "mirth" (Goel and Dolan, 2007), "amusement" (Giuliani et al., 2008), "happiness" (Dawkins et al., 2007), and even "exhilaration" (Ruch, 1995). In addition, positive emotion terms such as "joy" and "mirth" have been used somewhat interchangeably (Panksepp, 2000), and combined descriptors such as "happiness/amusement" (Roberts and Levenson, 2006) and "joy/laughter" (Block et al., 1991) are often used. This blending of terminology is confusing, and also at odds with theoretical positions asserting that positive emotions (e.g., joy and amusement) are not equivalent (Izard, 1977; Shiota et al., 2004). In the current study, we use the term "amusement" to refer to the emotion evoked by humorous material and "joy" to refer to the emotion brought about by well-being, success, or good fortune (Merriam-Webster Online, 2010). We use these terms rather than "happiness," which we believe may encompass or describe both of these emotional states.

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0167-8760/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.ijpsycho.2010.10.007

1.1. Previous research on differences among positive emotions

Early studies argued that there are unique experiential and behavioral profiles for the basic emotions of fear, disgust, sadness, anger, surprise, and happiness, and that these are accompanied by distinct patterns of autonomic nervous system (ANS) activation (Ekman et al., 1983). Although debated (Russell, 1980), it is generally agreed that the clearest distinctions in physiology are found when negative emotions are compared to positive emotions. Negative emotions are usually characterized by greater physiological activation and positive emotions are more often typified by physiological deactivation (Andreassi, 2007; Ekman et al., 1983; Fredrickson and Levenson, 1998; Fredrickson et al., 2000).

The growing interest in creating a more nuanced understanding of specific positive emotions (e.g., Shiota et al., 2004) has inspired researchers to look more closely at responses that may distinguish them from one another. Empirical evidence provides support for differences in both subjective experience and behavior among various positive emotions. For instance, several studies have found differences in self-reports between amusement and contentment (Christie and Friedman, 2004; Fredrickson and Branigan, 2005; Fredrickson et al., 2000). Differences have also been found among awe, amusement, and pride in emotional displays (Shiota et al., 2003) and between variants of "happiness" in facial electromyographic responses (Lang et al., 1993). Taken as a whole, these findings provide support for the idea that specific positive emotions, like negative emotions, involve distinct subjective and behavioral responses.

1.2. Comparisons of autonomic physiology among positive emotions

Few studies have directly compared physiological responses among positive emotions. In one study that used films to compare amusement and exhilaration, exhilaration was associated with decreases in cardiac pre-ejection period (PEP; suggesting greater sympathetic activation) and increases in heart rate (HR), whereas amusement was associated with increases in PEP and no changes in HR (Harrison et al., 2000). Another study, also using film clips, found no difference in cardiovascular reactivity between amusement and contentment (Fredrickson et al., 2000). Happiness (which may or may not be the same as joy, as noted earlier) has been associated with greater increases in HR than surprise (Cacioppo et al., 1998), and smaller increases in respiratory sinus arrhythmia (RSA) than sexual desire (Ritz et al., 2005). Studies of the effects of positive emotional stimuli on respiration rate and respiratory amplitude have revealed both increases and decreases in both of these indices (for review see Boiten et al., 1994). In sum, many more data are needed to begin to understand whether and how the positive emotions differ from one another autonomically.

In the present study we were particularly interested in examining cardiovascular and respiratory responses in amusement. The view that amusement has a distinct ANS signature has garnered both support (Ekman, 1999) and skepticism (Martin, 2007). One reason to expect differences between amusement and other positive emotions such as joy is the occurrence of laughter (Pearce, 2004), which may have multiple physiological effects. For example, laughter acts on the myocardium, causing increases in HR (Buchowski et al., 2007), and on the respiratory system, leading to more initial exhalations than inhalations, and causes frequent breaks or "interval pauses" during respiration (Fry and Rader, 1977). Much remains to be learned about specific physiological effects of laughter (Panksepp, 2000) and how they may contribute to differences in the architecture of amusement versus a comparable emotion that is not as characteristically associated with laughter, namely joy.

1.3. The current study

For the present study, we used film clips selected to evoke amusement and joy, and compared self-reported emotional experience, emotional facial behavior, and physiological responses (i.e., cardiovascular and respiratory) between the film stimuli. With respect to our physiological measures, in addition to HR, which captures both sympathetic and parasympathetic influences on the heart, we examined cardiac PEP as an indicator of cardiac sympathetic activation and RSA as an indicator of cardiac parasympathetic activation (Cacioppo et al., 1994). We also examined respiration rate and respiratory amplitude, which are typically negatively related to one another, as deeper respirations take more time.

We expected that participants would report emotion-specific subjective experience, namely greater amusement in response to the clip selected to elicit amusement, and greater joy in response to the clip selected to elicit joy. We also expected that participants would display more laughter and greater overall positive facial affect during the amusement clip than during the joy clip. Given our expectation that amusement would be accompanied by laughter, which in turn would exert respiratory influences on the myocardium, we expected amusement would be associated with more RSA and greater respiration rate (RR) and respiratory amplitude (RA) than joy. We also expected laughter to increase HR, as found in previous research (Buchowski et al., 2007). Although Harrison et al. (2000) reported an increase in cardiac PEP (suggesting sympathetic deactivation) during an amusing film, we made no specific prediction regarding PEP because other authors suggest that laughter is associated with sympathetic dominance (e.g., Sakuragi et al., 2002). Finally, to better understand the interplay among subjective experience, behavior, and physiology in amusement and joy, we conducted supplemental analyses to investigate the relations among these three components of emotion during the two emotion conditions.

2. Method

2.1. Participants

The sample included 39 undergraduate students (27 females) ranging in age from 18 to 54 years ($M = 21.5$, $SD = 7.3$). Participants were recruited through an online subject pool for students enrolled in psychology courses. Due to the potential influences of smoking, eating, and drinking on the ANS, smokers were excluded and participants were asked not to eat or drink anything 3 h prior to the experiment. The study was conducted in accordance with the Declaration of Helsinki and was approved by the university institutional review board. Participants provided written informed consent and received research participation credit.

2.2. Film stimuli

Two film clips were used to elicit amusement. One clip (Williams) was 206 s long and depicted comedian Robin Williams doing a standup routine featuring anecdotes about illicit drug use. The other amusing clip (Cosby) was 224 s long and featured comedian Bill Cosby doing a standup routine in which he discusses the challenges of growing up with his mother. The joy clip was 149 s long and featured the figure skater Sarah Hughes reacting to winning the Olympic gold medal at the 2002 Winter Olympic Games. Neutral and sad film clips were also included for a separate study but are not reported here because they are not relevant to the present study's aim of differentiating positive emotions.

The Williams and Cosby clips have been shown in previous research to evoke the specific target emotion of amusement (Goldin et al., 2005; Gross and Levenson, 1995; Hutcherson et al., 2005; Rottenberg et al., 2007). The Olympics clip has been used in prior studies to elicit "happiness" (Gruber et al., 2008, 2010; Werner et al., 2007); however, we used it with the assumption that it would elicit the target emotion joy, given our definition provided above.

2.3. Procedure

Upon arriving at the laboratory, participants were greeted by a trained research assistant who provided a brief overview of the study (e.g., "We are interested in how your body responds when you watch video clips") and offered to answer any questions; informed consent was then obtained. Next, a female research assistant measured height, weight, waist and hip circumference, and obtained an initial blood pressure reading to rule out hypertension. Quik-Trace diaphoretic foam spot electrodes were then applied to the neck and torso using a modified Lead II ECG placement to reduce artifacts and to produce a prominent QRS complex (Stern et al., 2001). Identical electrodes for impedance cardiography and impedance pneumography were applied using a Qu et al. (1986) spot electrode configuration. In a dimly lit 2.68 × 2.72 m area segregated from the researchers by a partition (as in Christie and Friedman, 2004), participants were seated in a comfortable armchair in front of a 19" computer monitor, approximately 1.02 m from their eyes. Participants then completed a demographic questionnaire and several psychosocial scales not relevant to the present study. The questionnaires took approximately 20 min to complete, allowing ample time for participants to acclimate to wearing the sensors.

Following the questionnaires, participants viewed five film clips (three of which were included for use in a different study). Each film clip was introduced with the instructions "Now I'll be showing you a short video clip. Please just watch the video monitor. Do you have any questions?" All participants viewed the neutral clip first and then saw three additional clips in counterbalanced order: the joy clip, one of the amusing clips (either Williams or Cosby), and the sad clip. The amusing clip that was not shown (i.e., either Williams or Cosby) was presented at the end of the session with specific viewing instructions not relevant to the present investigation; data from that viewing were not included in the current report. Each film clip was preceded by a 2-min baseline epoch and followed by a 2-min rest epoch. During these epochs participants were asked to simply sit quietly. Self-report ratings assessing participants' emotional reactions to the clips were completed after each rest epoch. Additionally, facial responses during the viewing epochs were video recorded using a Logitech QuickCam Orbit MP webcam that rested on top of the computer monitor. The study took approximately 2 h to complete. Afterward, participants were debriefed, and any questions they had about the study were answered.

2.4. Measures

Subjective emotional experience: Self-generated descriptors. Immediately after each rest period, participants rated their reactions to the clips in two different ways. First, they were asked to list the three most powerful emotions they felt while watching the clip. From these self-generated emotion descriptors, indicators of *amusement*, *happiness*, and *joy* were tabulated. Participants were given a 1 in each category for which they listed that emotion, and a 0 otherwise. Self-generated descriptors of "laughter," "humor," and "funny," in addition to "amusing" and "amusement," were counted as *amusement*; "happy" and "happiness" were counted as *happiness*, and "joy" and "joyful" were counted as *joy*.

Subjective emotional experience: Intensity ratings. After generating their own lists of emotions, participants then were presented with a list of 13 specific emotions, including the three target emotions of interest (i.e., amusement, happiness, and joy) and 10 distractor items[1] Participants were asked to rate the intensity with which they experienced each emotion during the film clip using 7-point Likert scales (1 = *not at all amused/happy/joyful*; 7 = *very amused/happy/joyful*).

Emotional behavior. For the Williams, Cosby, and joy clips, five trained coders, who were blind to which film clips the participants were watching, coded laughter and other expressive behavior using a modified version of Gross and Levenson's (1993) Emotional Expressive Behavior Coding System. Using a 4-point intensity scale (0 = *not at all*, 1 = *slight*, 2 = *moderate*, and 3 = *strong*), coders rated participants' facial expressions of general positive affect across 5-s intervals, then separately rated displays of laughter on a second-by-second basis. Coders' ratings were then averaged across the viewing period; thus, codes reflect both duration and intensity of the rated behavior. Because ratings of general positive facial affect included laughter, the positive facial affect and laughter codes were not mutually exclusive.

Our approach for computing reliability and comparing behavior between film clips followed Kunzmann, Kupperbusch, and Levenson (2005) and Roberts and Levenson (2006). Reliability was determined by having raters double-code videos from 13 participants (33% of the sample). Inter-rater reliability was assessed for positive facial affect and for laughter using intraclass correlation coefficients (ICCs), revealing ICCs of .76 and .60, respectively.[2]

Cardiovascular and respiratory responses. Physiological data (ECG and dZ/dt) were recorded using an impedance cardiograph from MindWare Technologies (Model 2000D; Gahanna, OH) with MindWare ACQ USB 1.31 acquisition software, and were digitized at 1000 Hz. Custom software from MindWare was used to edit, verify, and score these data, and five physiological indices were derived. 1) HR was quantified from ECG as the number of R–R intervals per minute. 2) To derive PEP, the ECG and dZ/dt data were ensemble-averaged for each minute. PEP was then quantified as the time interval in milliseconds from the onset of the ECG R wave from the ongoing Q wave to the B point of the concurrent ongoing dZ/dt wave (Berntson et al., 2004; Lozano et al., 2007; Sherwood et al., 1990). 3) To derive respiratory parameters from impedance data, the ΔZ waveform was decimated to 250 Hz, then low-pass filtered at .5 Hz to remove cardiac signals and high-frequency noise. Respiration rate was quantified as the number of peaks per minute in the processed ΔZ waveform, and 4) respiration amplitude was quantified as the amplitude in millimeters of the inspiratory portion of the processed ΔZ waveform (Ernst et al., 1999). 5) RSA was derived as described in Berntson et al. (1997). In this procedure, the interbeat interval series obtained from the ECG is time-sampled at 4 Hz (with interpolation) to produce an equal interval time series, which is then detrended using a second-order polynomial, end tapered, and submitted to a fast Fourier transformation. RSA spectral power is then integrated over the relevant frequency band for respiration (.15–.4 Hz). Although they were considered as outcomes on their own, respiration rate and respiratory amplitude were also tested as covariates in analyses of RSA due to their potential for altering RSA values (Grossman et al., 1991).

Data reduction. Scores for the five physiological indices were derived for each minute or fraction of minute; these scores were then averaged to create scores for the baseline and viewing periods. When comparing indicators of subjective experience, behavior, or physiological function across clips (our primary aim), each indicator was examined separately. However, prior to running supplemental analyses examining the interplay among these emotion components, composite scores were created in order to reduce the number of variables and enhance their reliability. The small number of subjects precluded the use of factor analysis. Therefore, composites were formed to represent each emotion component based on *a priori*

[1] Distractor items included anxiety, irritation, disgust, nervousness, sadness, anger, scaredness, shame, guilt, and interest.

[2] Facial display of general negative affect was also coded for these clips but was not reliable due to a very low base rate; hence it was not included in the present analyses.

theoretical considerations and the pattern of zero-order correlations among individual indicators (shown in Table 1). The selected indicators were converted to z-scores within each emotion condition, then averaged. Two different composites were created for subjective experience: one for amusement (comprising intensity ratings of amusement and happiness during the amusement clip), and one for joy (comprising intensity ratings of joy and happiness during the joy clip). The composites for behavior included positive facial expressions and laughter, and the composites for physiological response included HR, RSA, RA, and RR reactivity (PEP reactivity was omitted due to its lack of significant association with any other physiological response score).

3. Results

3.1. Preliminary analyses

Sequence effects. One-way ANOVAs revealed no sequence effects for any of the dependent measures involving the joy, Cosby, or Williams clips. Therefore, data for these clips from all the sequences were combined in subsequent analyses.

Comparison of two comedy clips. Because the participants were split in viewing either the Williams or the Cosby film clip, independent-sample *t*-tests were conducted on subjective, behavioral, cardiovascular, and respiratory data to examine potential differences between the two comedy clips. The Cosby clip received significantly higher joy ratings ($M = 4.6$, $SD = 1.1$) than the Williams clip ($M = 3.9$, $SD = 1.1$), $t\ (38) = -2.20$, $p = .034$. However, the two clips did not differ in amusement or happiness ratings, in number of self-generated *amusement*, *happiness*, or *joy* descriptors, or in any of the behavioral or physiological measures (all $ps > .05$). Therefore, data from the two comedy clips were combined for the remaining analyses and they are referred to collectively as the "amusement clip." Because the Cosby clip garnered higher joy ratings than the Williams clip, combining the two clips was a conservative strategy that potentially reduced any differences between amusement and joy.

Physiological baseline and reactivity scores. Initial repeated-measures ANOVAs comparing baseline physiological responses prior to each clip revealed no significant differences. Accordingly, we used change scores from the preceding baseline of each clip to its respective viewing period (i.e., reactivity) to assess differences between physiological effects of the amusement and joy clips.

Table 1
Pearson correlations among behavior, self-report, and physiological response measures during amusement and joy video clips.

	Self-generated "joy"	Self-generated "happiness"	Amusement intensity rating	Joy intensity rating	Happiness intensity rating	Facial positive affect	Laughter	HR reactivity	RSA reactivity	PEP reactivity	RA reactivity	RR reactivity
Amusement clip												
Self-generated "amusement"	−.128	.024	−.161	−.338*	−.040	−.203	−.085	.158	−.155	.006	−.019	−.107
Self-generated "joy"		.145	.074	.193	.209	.170	.010	−.143	−.027	.297	.199	−.087
Self-generated "happiness"			.130	.280	.489**	.269	.217	.182	.060	−.215	−.050	.217
Amusement intensity rating				.507**	.679**	.471**	.461**	.374*	−.092	−.320*	.014	.321*
Joy intensity rating					.696**	.248	.266	.117	.016	−.383*	−.088	.285
Happiness intensity rating						.409**	.353*	.346*	−.147	−.324*	.107	.198
Facial positive Affect							.686**	.477**	−.009	−.274	.061	.431**
Laughter								.695**	.084	−.181	−.253	.734**
HR reactivity									−.212	−.261	−.239	.619**
RSA reactivity										.063	−.435**	.191
PEP reactivity											.054	−.219
RA reactivity												−.394*
Joy clip												
Self-generated "amusement"	−.171	.065	.075	.050	.111	.195	.253	.122	−.135	−.051	−.094	−.067
Self-generated "joy"		.029	.042	.264	.167	−.175	−.206	−.157	−.030	−.084	.082	−.056
Self-generated "happiness"			.409**	.163	.190	−.224	.139	.096	−.063	−.129	.244	.165
Amusement intensity rating				.507**	.679**	.123	.202	.409**	−.118	−.294	.110	.072
Joy intensity rating					.696**	.073	.061	.235	−.042	−.311	−.046	.108
Happiness intensity rating						.115	.239	.323*	.135	−.289	−.134	.271
Facial positive Affect							.347*	.251	.065	−.053	.039	−.236
Laughter								.195	−.032	−.077	.087	−.047
HR reactivity									−.321*	−.113	.241	.369*
RSA reactivity										.035	−.412**	.004
PEP reactivity											.047	−.080
RA reactivity												−.064

Note. $N = 39$ except for correlations with facial positive affect and laughter during the joy clip, where $N = 38$ due to a technical problem with the video for one participant (reanalysis of all correlations using $N = 38$ did not appreciably change any result).
*$p < .05$. **$p < .01$.

3.2. Differences in subjective emotional experience between amusement and joy clips

To determine the extent to which the amusement and joy clips elicited the target emotions, indicators of subjective experience were compared between clips.

Self-generated emotion descriptors. Repeated-measures logistic regressions (using general estimating equations) with clip (amusement vs. joy) as the within-subject variable were conducted on the presence or absence of *joy*, *amusement*, and *happiness* reported as one of the three most powerful emotions experienced during each clip. Fourteen participants listed *joy* for the joy clip, whereas only seven listed *joy* for the amusement clip, Wald $\chi^2(1)=4.67$, $p=.031$. Only seven participants listed *amusement* for the joy clip, whereas 23 listed *amusement* for the amusement clip, Wald $\chi^2(1)=20.19$, $p<.001$. The number of participants listing *happiness* did not differ between the amusement and joy clips (see Table 2).

Emotion intensity ratings. Repeated-measures ANOVAs with clip (amusement vs. joy) as the within-subject variable were conducted on the joy, happiness, and amusement intensity ratings. Analyses revealed a significant difference between the clips for the amusement ratings, $F(1, 38)=13.09$, $p=.001$, $\eta_p^2=.26$, in which the amusement clip was rated significantly more amusing than the joy clip (see Table 2). No difference was found between the amusement and joy clips for the joy or happiness intensity ratings. As shown in Table 2, mean intensity ratings of amusement and joy elicited during the corresponding clips were very close to the middle value on the rating scale, suggesting that the elicited emotions were only moderate in strength (though within range for this type of research).

3.3. Differences in emotional behavior between amusement and joy

Repeated-measures ANOVAs with clip (amusement vs. joy) as the within-subject variable were carried out on coders' ratings of the participants' positive facial expressions and laughter displays during viewing of the clips. Analyses showed that the amusement clip elicited more overall positive facial affect, $F(1, 37)=32.84$, $p<.001$, $\eta_p^2=.47$, and more laughter, $F(1, 37)=12.42$, $p=.001$, $\eta_p^2=.25$, than the joy clip (see Table 2). Because ratings of positive facial affect and laughter were positively correlated during both clips, $r(39)=.69$, $p<.001$ for amusement; $r(38)=.35$, $p=.033$ for joy, an analysis of covariance with laughter as a covariate was carried out to further examine the effect of clip type on positive facial affect. Although laughter was a significant covariate, $F(1, 37)=5.55$, $p<.001$, the difference in positive facial affect between the amusement and joy clips remained significant, $F(1, 37)=15.42$, $p<.001$.

Table 2
Subjective experience, behavioral, cardiovascular, and respiratory data during amusement and joy clips.

Outcome variable	Amusement clip *n*	Joy clip *n*
Self-generated emotion descriptors[a]		
"Joy"	7_a	14_b
"Amusement"	23_a	7_b
"Happiness"	29_a	31_a
	M (SD)	*M (SD)*
Subjective intensity ratings		
Joy	$4.35\ (1.21)_a$	$4.50\ (1.65)_a$
Amusement	$4.93\ (1.38)_a$	$3.83\ (1.80)_b$
Happiness	$4.90\ (1.28)_a$	$4.72\ (1.70)_a$
Behavior		
Positive facial expression	$.69\ (.65)_a$	$.08\ (.15)_b$
Laughter	$.12\ (.21)_a$	$.001\ (.006)_b$
Physiological reactivity[b]		
Heart rate (HR)	$-1.50\ (4.90)_a$	$-3.10\ (3.90)_b$
Respiratory sinus arrhythmia (RSA)	$-.21\ (.70)_a$	$-.14\ (.51)_a$
Pre-ejection period (PEP)	$.71\ (6.97)_a$	$1.21\ (7.39)_a$
Respiratory amplitude (RA)	$.006\ (.021)_a$	$-.001\ (.005)_b$
Respiration rate (RR)	$.98\ (4.00)_a$	$1.98\ (3.64)_a$

Note. Film clip conditions with the same subscript do not differ ($p>.05$). Emotion intensity ratings could range from 1 (*not at all*) to 7 (*very*). Positive facial expression reflects average of all coder intensity ratings (on a 0–3 scale) for each 5-s interval of viewing. Laughter reflects average of all coder intensity ratings (0–3) for each 1-s interval of viewing. HR = heart rate; RSA = respiratory sinus arrhythmia; PEP = cardiac pre-ejection period; RA = respiratory amplitude; RR = respiration rate.
[a]Values represent number of participants (out of 39) who listed the given emotion as one of the top three emotions experienced while viewing the corresponding clip.
[b]Reactivity values represent change from baseline to viewing.

3.4. Differences in physiological reactivity between amusement and joy

Repeated-measures ANOVA with clip (amusement vs. joy) as the within-subject variable revealed a significant main effect of film clip on HR reactivity, $F(1, 38)=5.43$, $p=.025$, $\eta_p^2=.13$, in which there was a smaller HR deceleration for the amusement clip relative to the joy clip. A main effect of clip was also present for RA reactivity, $F(1, 38)=4.81$, $p=.035$, $\eta_p^2=.11$, in which there was a greater increase in RA for the amusement clip relative to the joy clip. There were no differences between clips in RSA (with or without covarying RA and RR), PEP, or RR reactivity.

3.5. Relations among subjective, behavioral, and physiological responses in amusement and joy

In these exploratory analyses, associations among the three emotion response systems were evaluated using a composite variable to represent each system, as described above. As shown in Table 3, the patterns of associations among composite scores differed substantially between the amusement and joy clips. Zero-order correlations among all three composite scores were significant and of moderate to large size during amusement, but none were significant during joy. Between-clip differences in correlation magnitudes were evaluated using zPF tests (Raghunathan et al., 1996). The associations between subjective experience and behavior and between behavior and physiological response were significantly larger during amusement than joy, $z(38)=2.34$, $p=.019$, and $z(38)=3.56$, $p=.002$, respectively. The association between subjective experience and physiological response did not differ significantly between emotion conditions.

Next, exploratory partial correlations between each pair of composite scores, while controlling for the third composite score, were estimated separately for each clip. These analyses suggested that behavior (either laughter, facial positive affect, or both) mediated the relationship between subjective experience and physiological responding for the amusement clip but not for the joy clip. We conducted the appropriate series of regression analyses (Baron and Kenny, 1986) to test for statistical mediation during amusement, and Sobel tests were carried out using an online computer software program (Preacher and Leonardelli, 2001). Results suggested that behavior mediated the relationship between subjective experience and physiological responding for the amusement clip, Mediation Effect (ME) $=.166$, $SE=.057$, $p=.004$. Follow-up regressions in

Table 3
Correlations between pairs of composite scores representing subjective experience, behavior, and physiological response during amusement and joy clips.

Composite scores		Amusement clip	Joy clip
Subjective experience	Behavior	.50**	.01
Behavior	Physiological response	.69***	.10
Subjective experience	Physiological response	.35*	.04

Note. $N=39$ except for correlations with behavior during the joy clip, where $N=38$ due to a technical problem with the video for one participant (reanalysis of all correlations using $N=38$ did not appreciably change any result).
*$p<.05$. **$p<.01$. ***$p<.001$.

which laughter and positive facial affect were tested separately revealed that laughter, but not positive facial affect, mediated the relationship between subjective experience and physiological responding, $ME = .149$, $SE = .056$, $p = .008$, and $ME = .056$, $SE = .030$, $p = .067$, respectively.

4. Discussion

The current study compared subjective, behavioral, cardiovascular, and respiratory responses, and the associations among these responses, for two specific positive emotions: amusement and joy. Amusement and joy arguably arise under different circumstances, are experienced as subjectively discriminable, and serve different social functions. Yet, they are often lumped together under the rubric of happiness, or positive emotion more broadly, which limits a more nuanced understanding of their roles in emotional functioning. Comparing these two emotions also provided an opportunity to examine the physiological correlates of laughter, which typically is associated with amusement but has been associated with joy as well. Using film clips to elicit amusement and joy, we found that there were differences between these two emotions in multiple subjective, behavioral, and physiological indicators. Specifically, compared with the joy clip, the amusement clip was rated as more amusing, and elicited more positive facial expressions, more laughter, smaller heart rate deceleration, greater increases in respiratory amplitude, and a higher level of coordination among response systems. Also, during amusement, laughter was uniquely related to heart rate and respiratory amplitude, above and beyond other subjective and behavioral indicators.

4.1. Subjective experience during amusement and joy clips

Differences in both self-generated emotion descriptors and rated intensity of emotions supported the effectiveness of the video clips in eliciting the discrete emotional states of amusement and joy. When asked to list, in an open-ended way, which emotions they felt most strongly in response to the clips, participants described feeling “amusement” more often in response to the comedy clip and “joy” more often in response to the Olympics clip. Participants also rated their experience of amusement as more intense in response to the comedy clip than to the Olympics clip, although they did not differ between the two clips in their intensity ratings of joy. Thus, although joy was not as consistently differentiated between the two film clips as amusement (i.e., based on the intensity ratings), our findings from open-ended reports of emotion indicated that individuals labeled particular positive emotional experiences as joy, rather than amusement. Notably, “happiness” was mentioned and rated with similar intensity for the two clips, showing its relative lack of emotion-specificity as a descriptor. We speculate that rather than describing a specific emotion, the term “happiness” may best reflect the general positive affect that underlies many discrete positive emotions (Barrett, 2006). Or to put it differently, “happiness” represents the consistent theme among the variations in the positive emotion family (Ekman, 1992).

4.2. Emotional behavior and physiological responses differed between amusement and joy

Findings for emotional behavior paralleled those for self-reported subjective experience in terms of revealing differences between amusement and joy. Specifically, participants displayed more positive facial affect and more laughter during the amusement clip than during the joy clip. Our findings support commonsense notions and previous findings (e.g., Mauss et al., 2005) regarding the association between feelings of amusement and displays of laughter. Despite previous accounts describing laughter as a characteristic response during joy (Panksepp, 2007), we observed almost no laughter during the joy clip. It may be the case that joy-related laughter does not occur at the moderate level of joy we were able to elicit in the current study. Alternatively, our definition of “joy” may differ from previous usage.

Amusement and joy differed on two indicators of physiological responding: heart rate and respiratory amplitude. Heart rate decelerated during both clips, which is a characteristic response to visual stimuli such as emotional films or slides (Bradley and Lang, 2007) as well as a response to positive (relative to negative) emotions (Ekman et al., 1983). Heart rate decelerations were smaller, however, during amusement than during joy. This difference may reflect physiological influences that increase heart rate during laughter, as documented by Buchowski et al. (2007). Another possible influence was that amusement was elicited directly, whereas joy was elicited vicariously. Vicarious emotion requires other-oriented responding, which can entail cardiac slowing (e.g., Fabes et al., 1994). On the other hand, both conditions included salient environmental stimuli known to enhance self-focus (e.g., cameras, reflective computer screen; Duval and Silvia, 2002), which can intensify emotion and enhance cardiac reactivity.

Notably, we did not find differences between amusement and joy for RSA or PEP, which are indices of two major contributors to cardiac activity (Berntson et al., 1991). With respect to RSA, it may be the case that laughter during the amusement condition disrupted our ability to obtain valid measurements. In addition, previous research has found RSA is associated with long-term tonic (trait-like) rather than short-term phasic (state-like) positive emotionality (Oveis et al., 2009), and therefore RSA may not have been a sensitive enough measure to differentiate among conditions in our short-term emotion induction.

Respiratory amplitude also increased more in response to the amusement clip than the joy clip, but respiratory rate was not different between the two. Although we cannot say for certain, we speculate that brief bursts of laughter influenced respiratory amplitude but were not sufficient to influence respiratory rate during the course of a short film clip.

4.3. Relations among experience, behavior, and physiology in amusement and joy

In addition to comparing amusement and joy with respect to each emotion component (i.e., subjective experience, behavior, and physiology), we considered the interplay of these components as a possible way to differentiate these two emotions. Of note, our study was not intended as an a priori test of coordination of response systems across multiple time points, however we viewed this as an opportunity to explore possible differences in coherence. In particular, because laughter is a behavior that engenders widespread stereotyped physiological changes (e.g., Buchowski et al., 2007; Fry and Rader, 1977; Provine, 2004), we suspected that laughter might create greater coordination of emotion components during amusement, and that such coordination would not be present to the same extent during joy. Consistent with this notion, we found moderate to strong associations among the three emotion components for amusement and a lack of any significant associations for joy. Follow-up analyses to tease apart these relationships revealed that laughter did in fact account for the stronger associations during amusement among subjective experience, behavior, and physiological responses. Thus, it may be the case that subjective and physiological responses in amusement and joy differ primarily according to the extent to which laughter occurs. These results are largely consistent with previous research by Mauss et al. (2005), who found a moderate to high degree of coherence in amusement, and also differences in the extent of coherence between different pairs of response systems. Our data revealed stronger associations between behavior and physiology, and between behavior and subjective experience, than between subjective experience and physiology. We speculate that because of its strong

reflexive quality, laughter may act as an "anchor" among response systems during amusement, thus increasing their coordination.

4.4. Limitations

Our findings are qualified by certain limitations. First, we used film clips to elicit emotion. Film clips are advantageous in terms of experimental control (e.g., vs. idiographic methods of emotion elicitation such as reliving an emotional memory) but potentially have limited generalizability, particularly given their presentation in an individual rather than social context (Levenson, 2003). Second, we included only one exemplar of joy and one of amusement for each participant. Thus, we operationalized amusement narrowly as a response to the humor of a stand-up comedy routine (which included negatively valenced content, such as family conflict and problems caused by illicit drug use), as opposed to playfulness or other social interactions in which amusement and laughter may occur (Provine, 1996), and joy as a response to another's success, namely an Olympiad winning a gold medal. Although it can be argued that specific emotions have specific antecedents (Mesquita and Frijda, 1992), certainly these constructs can be captured in other ways. Future studies may benefit from including content ratings of clips with mixed positive and negative emotional content. This would shed light on the question of whether other positive emotions, aside from amusement, are experienced positively within a negative context. In addition, given the central role laughter played in our findings, our results may speak more to the effects of laughter than to differences between amusement and joy per se. Third, although we were interested in examining sympathetic and parasympathetic correlates of amusement and joy independently (vs. heart rate, which reflects both), it may have been difficult to obtain reliable RSA readings during laughter because participants were not sitting quietly. It remains to be seen which predictors explain physiological change for joy, and how this is functionally different from amusement. Finally, as noted earlier, we conducted exploratory analyses to examine coordination among response systems in amusement versus joy. Measurement of between-system coherence may have been handicapped, however, by our method, which required retrospective (though immediate) reports of subjective experience and the averaging of both behavior and physiological responses over time (Rosenberg and Ekman, 1994).

4.5. Conclusion

The study of positive emotions has flourished over the last few decades, but has received limited attention in the literature on specific emotion response patterns. One of the roadblocks in this literature has been the assumption of relatively few positive emotions, with terms such as joy and amusement being used somewhat interchangeably. In an initial effort, the current study aimed to highlight the urgent need to clarify terminology in this area and to examine potential differences between emotional states elicited by humor and comedy (i.e., amusement) and emotional states elicited by good fortune (i.e., joy). We found the clearest differences between amusement and joy in amusement ratings, positive affect displays, heart rate, and respiratory amplitude. We also found laughter to be a key component in explaining these differences.

Along with a growing body of research, our findings suggest that although the term "happiness" may describe an overarching positive affective state, it is not sufficient to capture more specific positive emotional states. Although comedy clips are often used to evoke happiness or a general positive emotional state, researchers should be aware that their findings are specific to amusement and may not generalize to other positive emotional states. In particular, laughter evokes a higher-activation physiological state, characterized by cardiovascular and respiratory changes, that is different from "feeling good" more generally. Our findings underscore the importance of examining specific behaviors such as laughter in addition to positive facial expressions; had we not done so, we would have concluded that intensity of positive facial affect, rather than laughter specifically, distinguished between amusement and joy. In addition, differentiated subjective experience may be captured more fully by including participants' spontaneous reports of affective states along with more conventional intensity ratings based on a predetermined list of emotion terms. Finally, examining the interplay or coherence among emotion response systems may be another important avenue when attempting to differentiate specific emotions and their functions.

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