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Autonomic patterns during respiratory suspensions: Possible markers of Transcendental Consciousness

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Abstract

In two experiments, we investigated physiological correlates of transcendental consciousness during Transcendental Meditation® sessions. In the first, experimenter-initiated bells, based on observed physiological patterns, marked three phases during a Transcendental Meditation session in 16 individuals. Interrater reliability between participant and experimenter classification of experiences at each bell was quite good. During phases including transcendental consciousness experiences, skin conductance responses and heart rate deceleration occurred at the onset of respiratory suspensions or reductions in breath volume. In the second experiment, this autonomic pattern was compared with that during forced breath holding. Phasic autonomic activity was significantly higher at respiratory suspension onset than at breath holding onset. These easily measured markers could help focus research on the existence and characteristics of transcendental consciousness.

Descriptors: Skin conductance response, Heart rate deceleration, Transcendental Consciousness, Consciousness, Orienting, Transcendental Meditation

Subjective experiences during a Transcendental Meditation® session[1] can be generally classified into three qualitatively different categories or phases: (a) the progressive reduction of mental and physical activity, called the *inward stroke*, (b) complete mental quiescence in which thoughts are absent and yet consciousness is maintained, referred to as a state of Transcendental Consciousness, and (c) the progressive increase of mental and physical activity, called the *outward stroke* (Maharishi, 1972; Wallace, 1986). In this study, we investigated physiological patterns during Transcendental Consciousness experiences and tested whether these patterns could discriminate Transcendental Consciousness from other meditation experiences.

Most studies investigating physiological parameters during Transcendental Meditation sessions have compared variables averaged over extended periods, typically 5–20 min (Banquet, 1973; Fenwick et al., 1977; Hebert & Lehman, 1977; Stigsby, Rodenberg, & Moth, 1981). By averaging data over the entire meditation session, these studies combined the physiological patterns underlying the more active mental processing of the inward and outward strokes with those underlying the mental quiescence of Transcendental Consciousness. Mixing data from all three periods would have confounded tests of the existence and uniqueness of Transcendental Consciousness and the comparison of it with eyes-closed rest, relaxation techniques, and other meditation techniques.

Three studies have investigated physiological markers during Transcendental Consciousness experiences. Farrow and Hebert (1982) reported results from a series of experiments in which they correlated incidents of respiratory suspensions with experiences of Transcendental Consciousness. They defined a respiratory suspension as any breath period that was more than twice the average breath period during the initial eyes-closed rest period. They observed 161 respiratory suspensions in 28 individuals during Transcendental Meditation sessions, compared with 19 respiratory suspensions in 23 age-matched resting control individuals. In a second experiment, they asked 11 people to press a button after Transcendental Consciousness experiences. To ensure that the participants were blind to the hypotheses being tested, the authors applied heart rate and skin conductance electrodes (but did not record these signals) and measured respiration covertly with a two-channel magnetometer. All participants pressed buttons during the Transcendental Meditation session, but only 8 of the 11 participants also exhibited respiratory suspensions. Among those eight individuals, 36 of 84 button presses occurred within 10 s of the offset of 1 of 56 respiratory suspensions (64% hits). These data suggest that respiratory suspensions will probably be one of a constellation of variables characterizing Transcendental Consciousness, if Transcendental Consciousness can be characterized by a specific, measurable physiological pattern.

Badawi, Wallace, Orme-Johnson, and Rouzeré (1984) replicated and extended these findings. They reported 52 respira-

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[1]Transcendental Meditation® is registered in the U.S. Patent and Trademark Office as a trademark of Maharishi Foundation, Ltd.

tory suspensions during Transcendental Meditation sessions in 54 individuals and none in 31 nonmeditating resting controls. They then compared electroencephalogram (EEG), spontaneous skin conductance response, and heart rate in 11 individuals during 19 respiratory suspensions and under two comparison conditions: during equal-length periods before and after respiratory suspensions (within subjects) and during voluntary breath holding (between subjects). Respiratory suspensions were distinguished from the other two conditions by significant decreases in theta power and significant increases in 0–50-Hz global coherence (all pairs of EEG sites measured), but no consistent differences in spontaneous skin conductance response or heart rate were observed.

In a third study, Travis (1993) also investigated autonomic and EEG variables during respiratory suspensions. Because button presses require attending to and evaluating experiences, which could interfere with the Transcendental Meditation technique, an extensive posttest interview was used to link physiological patterns to subjective experiences of Transcendental Consciousness. In this study, 6 of 20 individuals reported Transcendental Consciousness experiences. These experiences were marked by skin conductance responses and phasic heart rate deceleration at the onset of either respiratory suspensions or abrupt 40% decreases in breath volume. Also, during respiratory suspensions periods, the peak of EEG power and coherence in the 6–10-Hz band was significantly greater than that during equal-length periods before and after. However, there were large individual EEG differences in frequency bands (7.0–9.5 Hz) and in scalp locations (frontal, central, or parietal).

These autonomic changes at the onset of breath changes are similar to those reported during orienting to novel or significant stimuli (Spinks, Blowers, & Shek, 1985; Vossel & Zimmer, 1989). Travis (1993) suggested that this phasic autonomic activity may mark the transition of awareness from active thinking processes to the silent but alert state of Transcendental Consciousness.

These studies indicate that changes in breath, autonomic, and EEG patterns may be markers of Transcendental Consciousness experiences. In the current investigation, we explored this psychophysiological relationship with two experiments. In the first, we sought to replicate the pattern of physiological changes—respiration suspensions, phasic autonomic activity, and EEG power changes—as markers of Transcendental Consciousness experiences, using a new paradigm. Rather than using button presses, which require the participant's continued vigilance during the session, the experimenter rang a quiet bell when the participant's physiological patterns indicated one of three meditation phases. After the experiment, participants recorded what they had experienced just before each bell ring. Subjective and objective ratings were compared, along with the physiological variables during each phase. In the second experiment, we investigated physiological patterns during voluntary breath holding to test whether this physiological pattern could be produced intentionally, divorced from Transcendental Consciousness experiences, thus beginning to address the specificity of the previously observed patterns to Transcendental Consciousness experiences.

EXPERIMENT 1

Method

Participants

Sixteen graduate students were asked to participate in this study (6 women, 10 men; age: M = 35.0 years, SD = 10.5 years, range = 24.3–42.5 years), all of whom had been practicing the Transcendental Meditation technique for an average of 12.6 years (SD = 9.0 years, range = 0.4–22.5 years). Individuals practicing the Transcendental Meditation technique were used in this experiment because (a) all were familiar with the concept and experience of Transcendental Consciousness, (b) all had a shared terminology to describe their experiences, and (c) the intent of the study was to identify objective correlates of Transcendental Consciousness rather than to test whether this experience was unique to the Transcendental Meditation technique. Once this marker has been identified, then similar experiences may be investigated in other populations and during the use of other techniques. Also, the time course and critical factors for the emergence of Transcendental Consciousness experiences can be investigated.

Apparatus

EEG was recorded on a Grass 78D polygraph with a 1.0-Hz low filter, a 100-Hz high filter, and 5 μV/mm sensitivity. Electrodermal activity was recorded by Ag/AgCl electrodes with 1-cm double-stick collars, using K-Y® Jelly as conductive paste. Electrodermal activity was recorded on a Grass Model 78D polygraph with a constant 10 μA current across the electrodes and a sensitivity of 10.0 kΩ/cm. Heart rate was recorded with a Lead II configuration, right wrist to left leg. Breath rate was recorded with a Grass TCT-1 nasal thermistor.

Procedure

After participants washed their hands with soap and water, Ag/AgCl electrodes were secured to the distal phalanges of the left index and middle fingers with double-stick collars (Scerba, Freedman, Raine, Dawson, & Venables, 1992). EEG electrodes were applied with the Electro-Cap system (all 19 leads in the International 10-20 system [Jasper, 1958] referenced to linked mandibles, with impedances below 5 kΩ), and heart and breath sensors were attached. Participants then moved into a sound-attenuated room with a closed-circuit video monitor. Physiological measures were recorded on a Brain Atlas III (Biologic Systems) during an eyes-open session (2 min), an eyes-closed session (2 min), and a Transcendental Meditation session (20 min). (Data from the eyes-open and eyes-closed periods will be reported elsewhere.)

During the Transcendental Meditation session, the experimenter (F. Travis[2]) rang a quiet bell at approximately equal intervals when he judged, by the physiological records, that the participant was in one of three meditation phases: inward stroke, Transcendental Consciousness, or outward stroke. This procedure resulted in three experience probes per session. Table 1 contains the criteria used to mark each phase. The criteria for the inward and the outward strokes were based on work by Taneli and Krahne (1987), who asked individuals to press a button immediately after the outward stroke during a Transcendental Meditation session. All button presses occurred after a period of desynchronized EEG and were followed by global synchronized alpha when the individual continued with the inward stroke of meditation. The criteria for Transcendental Consciousness experiences were based on Travis's (1993) findings.

[2]Travis has practiced the Transcendental Meditation technique for 23 years and has researched the psychophysiological correlates of Transcendental Meditation practice for the last 10 years.

Table 1. *Criteria for On-line Classification of Subjective Experiences During a Transcendental Meditation Session*

	Experience category		
Physiological variables	Inward stroke	Transcendental Consciousness	Outward stroke
Breath suspension[a]	no	yes	no
Abrupt reduction in breath volume[b]	no	yes	no
Heart rate deceleration[c]	no	yes	no
Skin conductance response[d]	no	yes	no
EEG[e]	yes	yes	no

[a]At least twice the average resting breath period. [b]At least 30% decrease in peak/nadir of breath cycle compared with the two prior breaths. [c]At least 8 bpm decrease in a 1–3-s window following onset of breath changes. [d]At least 0.2 μS increase in a 1–3-s window following onset of breath changes. [e]Alpha activity at frontal, central, and parietal leads.

The 2-min segments of EEG, which included each bell ring during the Transcendental Meditation session, were digitized on line at 256 points/s. These EEG data were stored for later analyses. All physiological measures were continuously recorded on paper.

After the recording session, but before speaking with the experimenter, the participants were asked to classify their experiences during the approximately 20-s period before each bell ring. They were asked to use the following criteria: (a) for the inward stroke, free-flowing mental activity with a sense of relaxation; (b) for Transcendental Consciousness, complete mental quiescence in which thoughts were absent and yet self awareness was maintained; and (c) for the outward stroke, being lost in thought and oblivious to the surroundings or a sense of increased physical and mental activity.

Although no one reported difficulty in making this forced-choice response, in retrospect, it would have been preferable to include a fourth category, *none of the above*. In addition, it would have been better to signal participants during periods with ambiguous physiological indicators; for instance, respiratory suspensions without autonomic responses.

Data Quantification

Breath period, phasic autonomic activity, and EEG spectral estimates were calculated during the 20-s period before each bell ring; 20 s was long enough to include all respiratory suspension periods.

There is disagreement on the number of data points necessary to obtain stable spectral estimates of the scalp-recorded EEG. Tomarken, Davidson, Wheeler, and Kinney (1992), investigating temporal stability and internal consistency of anterior alpha during an eyes-open and an eyes-closed period, reported that stability will be underestimated when less than 4–5 min of data (six 43-s average-length periods) are used in the spectral estimates. However, Dumermuth and Molinari, (1987a, p. 91) concluded that there is "no definite general answer" to this question. They suggested that the research question determines the epoch length, with longer epochs being appropriate to address questions about spontaneous background activity (the intent of Tomarken et al.'s work) but shorter epochs being superior for assessing responses to stimuli and physiological patterns underlying tasks (Dumermuth & Molinari, 1987b). They also cautioned that long epochs may violate the stationarity assumption for spectral analysis. In the current study, using a period longer than 20 s would have mixed physiological patterns of Transcendental Consciousness with other phases of meditation, confounding the very comparison being studied. Therefore, in light of these considerations, 20-s segments of data were used, accepting that the error variance for the spectral estimates may be greater owing to potential instability of shorter blocks of data.

The longest breath period in the 20-s period was calculated. Breath period was used instead of breath rate to eliminate the possible confound of different baseline respiration rates. For example, an average breath rate of eight breaths/min could result either from slow regular breathing with no respiratory suspensions or from faster breathing with an extended respiratory suspension. Breath volume was inferred from the peak/nadir of the breath cycle as plotted by the polygraph for all breaths in the 20-s window. Any breath cycle with an inhale/exhale that was less than 70% of the average of the two preceding cycles was noted.

Heart rate deceleration and skin resistance were calculated in a 1–3-s window from the onset of breath changes during those experience probes with respiratory suspensions. This interval was chosen because it is the recommended window for calculating skin conductance response (Levinson & Edelberg, 1985) and heart rate response (Graham & Clifton, 1966; Vossel & Zimmer, 1989) to external stimuli. Phasic autonomic responses to the inner experience of Transcendental Consciousness—if that is what respiratory suspensions signal—would seem likely to follow the same time course as responses to outer stimuli. Skin resistance was calculated just prior to the respiratory suspension and at the peak amplitude in the 1–3-s window. These skin resistances were converted to skin conductance levels ($\mu S = 1{,}000/k\Omega$; Dawson, Schell, & Filion, 1990), and then differences were obtained to yield the magnitude of skin conductance responses. Heart rate deceleration in the same 1–3-s window was calculated from the tachiogram.

For experience probes without respiration changes, the maximum skin conductance response and heart rate deceleration was calculated in the 20-s period. Skin conductance responses and heart rate deceleration during these 20-s periods probably result in part from random events not directly related to the practice of the Transcendental Meditation technique. For instance, strong emotions or intense inner speech are reported to generate spontaneous skin conductance responses (Nikula, 1991), and heart rate variability also results from interaction with the respiratory cycle (respiratory sinus arrhythmia; Porges, 1995; Porges, McCabe, & Yongue, 1982). However, autonomic variables were calculated for these periods to manually approximate the steps an automated system might use to discriminate between phases of meditation. This approach was conservative and required more robust physiological changes during transcendental consciousness experiences to significantly discriminate between phases.

EEG was conditioned with a Hanning window, spectral analyzed in 1-s epochs and then averaged over the 20-s analysis period. (The Biologic spectral analysis routine does not overlap epochs to recover degrees of freedom lost due to windowing.) These spectral estimates were used to calculate theta (4–8 Hz) and alpha (8–12 Hz) power at the seven frontal electrodes (Fp1, Fp2, F7, F3, Fz, F4, F8) and six central-parietal electrodes (C3, Cz, C4, P3, Pz, P4). This yielded four scores: two regions × two frequency bands.

Data Analysis

Two research questions were tested. First, did respiration changes with phasic autonomic activity reliably discriminate Transcendental Consciousness experiences from other experiences during a Transcendental Meditation session? Second, did EEG variables also discriminate between meditation experiences? Autonomic and EEG variables were analyzed separately in light of prior research that has shown consistent autonomic changes, but various EEG changes, during reported Transcendental Consciousness experiences.

Two basic analysis strategies were used. First, interrater reliabilities were assessed between the participants' classifications of experiences, the experimenter's on-line physiologically based classification, and a second rater's off-line classification. Second, two analyses of variance (ANOVAs) were run to determine possible condition differences: one with EEG variables and the other with breath and autonomic variables.

Results

The Transcendental Meditation technique is a dynamic process. Although each session begins with the inward stroke, the condition of the physiology (i.e., the degree of rest or the amount and quality of prior activity) determines the duration of each phase and the transitions between phases throughout that meditation session (Maharishi, 1969, 1972). Individuals typically cycle though the inward stroke, Transcendental Consciousness (albeit briefly), and the outward stoke many times in each Transcendental Meditation session; however, specific experiences cannot be intentionally produced at specific times, and experiences vary within and between individuals. In the current study, the experimenter was able to mark with bell rings clear experiences of all three phases of meditation for only 3 of the 16 participants. For eight additional participants, he was able to mark the experience of both the inward stroke and Transcendental Consciousness but not the outward stroke during this experimental session. Data during the inward stroke and Transcendental Consciousness experiences were analyzed and are reported here only for these 11 individuals because each participants contributed equally to all cells.

Sequence of Phases Within a Transcendental Meditation Session

Across these 11 participants, incidences of the inward stroke and Transcendental Consciousness were fairly evenly distributed throughout the meditation session. Of 11 reported Transcendental Consciousness experiences, 2 occurred in the beginning, 4 in the middle, and 5 at the end of the Transcendental Meditation session. Of 11 reported inward stroke experiences, 4 occurred in the beginning, 3 in the middle, and 4 at the end. Therefore, elapsed time within the Transcendental Meditation session did not seem to substantially interact with phase.

Classification of Experiences

Because the data were categorical, Cohen's kappa was used to test interrater reliability of experience classifications (Rosenthal & Rosnow, 1991). Between the experimenter's and the participants' classification, the correlation coefficient was substantial, $\kappa = .650$, $t(10) = 2.56$, $p < .025$.[3] The experimenter and participant agreed on 10 out of 11 Transcendental Consciousness experiences (91% accuracy) and 9 out of 11 inward stroke experiences.

After the data were acquired, a research assistant, who was not involved in data acquisition, was given the physiological criteria in Table 1 and practiced classifying records from another study. Following this training, he independently assigned an experience category to each bell ring that was indicated on the paper records from this study. The interrater agreement was high, $\kappa = .755$, $t(10) = 3.39$, $p < .005$. Also, the association of the research assistant's classification with that of the participants was substantial, $\kappa = .621$, $t(10) = 2.38$, $p < .025$. The effect sizes of these correlations were calculated (Cohen, 1977) and were all very large ($d > 1.5$).

Physiological Patterns During Transcendental Consciousness and the Inward Stroke

Table 2 presents means and standard errors for physiological variables for these 11 subjects during the inward stroke (left column) and Transcendental Consciousness (right column). Breath period and magnitude of heart rate deceleration and skin conductance responses were greater during Transcendental Consciousness. Also, theta power was lower and alpha power higher during Transcendental Consciousness experiences than during the inward stroke.

Because ANOVAs are highly sensitive to outliers, the data were temporarily transformed to z scores. Any value above three standard deviations was considered an outlier (Stevens, 1984). Breath period and the autonomic variables were all below this criterion, and their distribution did not differ significantly from normality (Kolmogorov-Smirnov one-sample test of normality; skewness < 1.0), so further analysis of autonomic variables was conducted on the actual values. The EEG data, however, had three outliers (z scores ranging from 3.0 to 3.5), and the data differed significantly from normality (two-tailed $p < .001$; skewness ranged from 1.013 to 2.16). Therefore, the EEG data were log transformed, which produced more normal plots (skewness ranged from -0.165 to 0.770), before they were analyzed.

A $2 \times 2 \times 2$ ANOVA with one between-subjects variable (phase: inward stroke and Transcendental Consciousness), two within-subjects variables (frequency: theta and alpha; region: frontal and central-parietal), and log EEG power as the dependent variable revealed no significant main effects for phase, two-tailed $t(87) = 1.195$, *ns*). There were significant main effects for location, two-tailed $t(87) = 2.41$, $p < .02$, with significantly higher power at central-parietal leads, and for frequency, two-tailed $t(87) = 2.58$, $p < .015$, with significantly higher alpha than theta power during both phases of meditation. There were no significant two-way or three-way interactions. The effect sizes for theta decreases and alpha increases during Transcendental Consciousness were medium in size. The values for d ranged from 0.4 for alpha increases to 0.6 for theta decreases.

A single variable multivariate ANOVA (MANOVA) with two levels of phase and three dependent variables (breath period, skin conductance response, and heart rate deceleration) revealed a significant main effect for phase, Wilk's λ $F(3,18) = 3.33$, $p < .045$. The effect sizes for the three variables individually were

[3]The t statistic was derived from the correlation coefficient using $t = r * [(n-2)/(1-r^2)]^{1/2}$ (Bruning & Kintz, 1977).

Table 2. *Means (SE) of EEG and Autonomic Variables During the Inward Stroke and During Transcendental Consciousness Experiences*

Parameter	Inward stroke	Transcendental Consciousness
EEG variables		
Theta frontal power (μV^2)	1,868 (335)	1,443 (215)
Theta central-parietal power (μV^2)	1,831 (421)	1,524 (234)
Alpha frontal power (μV^2)	2,060 (455)	2,167 (438)
Alpha central-parietal power (μV^2)	3,547 (643)	4,491 (864)
Autonomic variables		
Breath period (s)	5.7 (0.5)	8.6 (1.0)
Heart rate deceleration (bpm)	6.3 (1.3)	11.3 (1.9)
Skin conductance response (μS)	0.09 (0.06)	0.42 (0.10)

Note: Absolute power is presented here. The log of these values was used for statistical testing.

large (all $d > 1.1$), and individual comparisons revealed significant phase differences for each variable, breath period: $F(1,20) = 6.88$, $p < .02$; heart rate variability: $F(1,20) = 4.50$, $p < .05$; and skin conductance response: $F(1,20) = 7.09$, $p < .015$.

The data suggest that respiratory suspensions or marked reduction in breath volume with skin conductance responses and heart rate deceleration mark the onset of Transcendental Consciousness periods and could discriminate this phase during a Transcendental Meditation session from other meditation experiences.[4] The next experiment tested whether phasic autonomic activity always occurs at the onset of respiratory suspensions, even voluntary breath holding, and therefore is not specific to breath suspensions during Transcendental Consciousness periods. The discussion following this experiment examines the results from both experiments.

EXPERIMENT 2

Method

Participants

Eleven undergraduate students (five women, six men) were invited to participate in this study. They had an average age of 20.5 years ($SD = 2.2$ years, range = 17.7–25.0 years) and had been practicing the Transcendental Meditation technique for an average of 6.1 years ($SD = 3.5$ years, range = 3.3–9.3 years). These individuals were younger than those in the first experiment but still had extensive experience with the Transcendental Meditation technique. Because we are investigating the basic physiological relationship between breath patterns and autonomic activity, which we assume to be invariant across these ages, these differences in age should not seriously bias the results.

Procedure

The electrode placement and procedures were the same as in the first experiment. In addition, at the end of the protocol, participants were asked to hold their breath for 15-20 s, breathe normally two to three times, and then hold their breath again; they repeated this four or five times. We did not signal the participants to begin and end breath holding because they would have oriented to the instruction, confounding the intended comparison.

Results

Skin conductance response and heart rate deceleration were calculated in a 1–3-s window following the onset of breath holding. These phasic autonomic patterns were compared with those seen at the onset of spontaneous respiratory suspensions in the subjects in the first experiment.

Breath patterns during voluntary breath holding differed markedly from those during respiratory suspensions. Voluntary breath holding usually commenced with a large inhale and ended with compensatory breathing. Also, the thermistor trace during voluntary breath holding was completely flat, without the small fluctuations reflecting the heart/lungs interaction seen during Transcendental Consciousness experiences.

Autonomic patterns also differed markedly between conditions. Table 3 presents means and standard errors for magnitude of skin conductance response (left column) and heart rate deceleration (right column) at the onset of voluntary breath holding (top) and spontaneous breath suspensions (bottom). The magnitude of skin conductance response and heart rate deceleration were greater at the onset of spontaneous respiratory suspensions than at the onset of voluntary breath holding. A single-variable MANOVA with two levels of condition (spontaneous and voluntary respiratory suspensions) and two dependent variables (skin conductance response and heart rate deceleration magnitudes) tested possible condition differences. There was a significant main effect for condition, Wilks λ $F(2,19) = 9.5$, $p < .001$. Also, individual comparisons revealed significant condition differences for each variable separately, skin conductance response: $F(1,20) = 7.79$, $p < .015$; heart rate deceleration: $F(1,20) = 11.45$, $p < .002$. The effect sizes were again very large for both variables ($d > 2.7$).

Discussion

These data extend earlier findings. Farrow and Hebert's (1982) and Badawi et al.'s (1984) work suggested an outcome relationship between breath suspensions and Transcendental Consciousness experiences. The current study is the first step towards

Table 3. *Means (SE) of Magnitude of Skin Conductance Response and Heart Rate Deceleration During Voluntary Breath Holding and During Spontaneous Breath Suspensions*

	Skin conductance response (μS)	Heart rate deceleration (bpm)
Voluntary breath holding	0.14 (0.09)	2.4 (3.4)
Spontaneous breath suspensions	0.42 (0.10)	−11.3 (1.9)

[4] A descriptive discriminant analysis (Huberty, 1984) generated loadings for breath period (0.788), heart rate response (0.637), and skin conductance response (0.799) that successfully classified 9 of the 11 transcendental consciousness experiences. The two misclassified experiences included abrupt breath volume reductions with autonomic responses rather than breath suspensions, emphasizing the need to monitor both types of breath patterns to discriminate Transcendental Consciousness experiences.

testing the property of specificity (Cacioppo & Tassinary, 1990) of this relationship. The physiological pattern of breath suspensions or marked reductions in breath volume, skin conductance responses and heart rate deceleration accurately marked 10 of 11 Transcendental Consciousness experiences and discriminated them from other meditation experiences. In the second experiment, breath patterns and phasic autonomic activity were significantly lower at the onset of voluntary breath holding than at the onset of spontaneous respiratory suspensions research. Further research will test the generality of this relationship—if it is seen across situations (both during and outside of a Transcendental Meditation session) and individuals (in other individuals reporting a similar experience but not practicing the Transcendental Meditation technique)—and will further test the specificity of the relationship—if this physiological pattern covaries only with changes in Transcendental Consciousness experiences.

Skin conductance changes may have been detected in this study but missed by earlier researchers because of improved methodologies. Previous researchers used palmar skin conductance, whereas in the current study we recorded electrodermal activity from distal phalanges, which are reported to be more sensitive to changes in sympathetic activity (Scerba et al., 1992). Also, previous researchers used EC-2 cream (Farrow & Hebert, 1982, p. 139), an electrode gel with saturated salt concentrations that "will result in a continuous fall of SCL and SCR amplitude over time" (Venables & Christie, 1973, p. 80)—exactly what previous researchers reported during respiratory suspensions. In the current study, we used K-Y Jelly, which Grey and Smith (1984) reported was comparable (for measuring skin conductance responses) to a custom NaCl paste similar to that recommended by Fowles et al. (1981). Future studies using the recommended Unibase gel are needed to replicate these skin conductance findings during Transcendental Consciousness.

EEG differences between Transcendental Consciousness and the inward stroke observed in this study (decreased theta and increased alpha power) were also reported by Badawi et al. (1984). In the current study, these EEG differences did not reach significance because of high interindividual variability. As seen in the general population (Nuñez, 1981), 2 of the 11 participants (20%) did not exhibit eyes-closed posterior alpha, and likewise they did not exhibit peaks in anterior or posterior theta or alpha activity during their Transcendental Meditation session. Variability may have been further increased by the short epochs used and the software limitations on overlapping epochs before spectral analyses. From these data, autonomic variables seem more robust and reliable as markers of Transcendental Consciousness experiences than EEG. Compared with EEG measures, breath and autonomic differences (a) were larger in effect size, (b) were seen before all respiratory suspensions periods in experience probes identified as containing Transcendental Consciousness experiences, and (c) could be used to correctly classify 9 out of 11 Transcendental Consciousness experiences in a multiple discriminant analysis.

Social Desirability: A Possible Alternative Explanation

Because these participants all practiced the Transcendental Meditation technique, they likely wanted to "make the experiment work." Participants could have been aware of earlier studies linking breath changes with Transcendental Consciousness experiences and so may have reported a Transcendental Consciousness period whenever their breath was very shallow before a bell ring.

This could have been a major confound if the mean difference in breath period during the inward phase and Transcendental Consciousness was large, for instance, 20–30 s. However, mean breath period differed by only 3 s between phases (5.7 vs. 8.6 s). Because the participants classified their experiences at the end of the 20-min session, it does not seem likely that they could use such small differences in breath period as their criterion. It seems more reasonable that a qualitative shift in experience, as reflected in the phasic autonomic activity at respiratory suspension onset, would be remembered at the end of the 20-min session and would be used as the basis for classifying experiences.

This conclusion is supported by the participants' descriptions of Transcendental Consciousness experiences. None mentioned changes in breathing in their descriptions. Rather, typical reports were "I was unaware of my body," or "I experienced deep silence," or "I experienced waves of intense happiness." Therefore, social desirability would not seem to account for these data.

Possible Impact of the Forced Choice of Subjective Experiences

The primary impact of not giving a fourth or *other* category for classification of experiences during a Transcendental Meditation session was probably to add noise to the data. Any experience that was in reality a mixture of phases would have been forced into one or another category. Perhaps all the experiences classified as Transcendental Consciousness by these participants were not "pure" Transcendental Consciousness experiences but included other psychological experiences and corresponding physiological patterns. Despite this possible confound, the interrater reliability was significantly better than chance, and the resulting autonomic variables were significantly different during the inward stroke from those during the Transcendental Consciousness experiences. Therefore, this confound did not seem to fatally affect these results. It is, however, an important design issue for future research.

Consideration of Breath Patterns During Transcendental Consciousness

During the respiratory suspensions, small fluctuations were seen in the breath trace, that is, it was not absolutely flat, probably because of the mechanical interaction between the heart and lungs, a relationship known since 1905 (Haldane & Priestly, 1905). During the systole phase when the blood is ejected, a vacuum is created in the lung cavity, drawing the air in; during the diastole phase, the heart fills with blood, pushing the air out (Fukuchi, Roussos, Macklem, & Engel, 1976).

Although breath appeared to be suspended during Transcendental Consciousness, suggesting apneas, Kesterson and Clinch (1989), using a spyrometer, reported that slow inhalation or apneusis occurs during these periods. Apneustic breathing was not detected in the present study because the Grass nasal thermistors used were not sensitive to very slow breath flow.

Fully developed apneustic breathing is rare in humans. Clinically, it is thought to reflect damage to the respiratory control centers located at the mid or caudal-pontine levels, approximately at and below the location of the nucleus parabrachialis (Plum & Posner, 1980). However, in the current study, all participants reporting Transcendental Consciousness were healthy and did not report past diseases or accidents that would have resulted in brainstem damage. Also, these individuals exhibited apneustic breathing only during reported Transcendental Consciousness experiences, and these apneuses lasted an average of 8.5 s, in contrast to the 2-3-s durations in clinical reports.

Kesterson and Clinch (1989) theorized that apneustic breathing during Transcendental Consciousness suggests that breath during this period is driven by different brainstem nuclei, namely the parabrachialis medialis, which respond to changes in O_2 concentrations rather than changes in CO_2 concentrations (Plum & Posner, 1980). The parabrachialis medialis are located in the same area of the lateral pons as the raphe and locus coeruleus, whose activities are responsible for modulating waking and sleeping (Imeri, Moneta, & Maria, 1988; Steriade, McCormick, & Sejnowski, 1993) and the REM-on cells that become active during phasic REM (Sakai, 1988).

Parallels Between Autonomic Patterns at the Onset of Transcendental Consciousness and Autonomic Patterns During Orienting

Skin conductance response and heart rate deceleration are markers of orienting—attention switching to environmental stimuli that are novel (O'Gorman, 1979; Sokolov, 1963) or significant (Maltzman, 1977; Spinks et al., 1985). Orienting is characterized by a delay in respiration that is followed by slower, deeper breathing, marked skin conductance responses and heart rate deceleration, desynchronized EEG, dilation of cerebral blood vessels and constriction of peripheral blood vessels, and increased sensitivity of the sense organs (Cacioppo & Petty, 1983). This physiological response pattern is similar to the pattern observed at the onset of respiratory suspensions in the current study.

We suggest that skin conductance response and heart rate deceleration at the onset of breath changes during a Transcendental Meditation session mark the transition of awareness from active thinking processes to the mental quiescence of Transcendental Consciousness. This skin conductance orienting was not in response to a novel experience; it was seen repeatedly in a single 20-min Transcendental Meditation session and in individuals with extensive Transcendental Meditation experience. Rather, the observed skin conductance orienting suggests that Transcendental Consciousness is a significant experience to these individuals and that this distinct subjective experience has distinguishing physiological markers. Further studies will shed light on the neural mechanisms underlying Transcendental Consciousness and its relationship to other experiences and states of consciousness.

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