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Gas Discharge Visualization Evaluation of Ultramolecular Doses of Homeopathic Medicines Under Blinded, Controlled Conditions

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ABSTRACT

Objectives: To determine the feasibility of using a computerized biophysical method, gas discharge visualization (GDV), to differentiate ultramolecular doses of homeopathic remedies from solvent controls and from each other.

Design: Blinded, randomized assessment of four split samples each of 30c potencies of three homeopathic remedies from different kingdoms, for example, Natrum muriaticum (mineral), Pulsatilla (plant), and Lachesis (animal), dissolved in a 20% alcohol-water solvent versus two different control solutions (that is, solvent with untreated lactose/sucrose pellets and unsuccussed solvent alone).

Procedures: GDV measurements, involving application of a brief electrical impulse at four different voltage levels, were performed over 10 successive images on each of 10 drops from each bottle (total 400 images per test solution per voltage). The dependent variables were the quantified image characteristics of the liquid drops (form coefficient, area, and brightness) from the resultant burst of electron-ion emission and optical radiation in the visual and ultraviolet ranges.

Results: The procedure generated measurable images at the two highest voltage levels. At 17 kV, the remedies exhibited overall lower image parameter values compared with solvents (significant for Pulsatilla and Lachesis), as well as differences from solvents in fluctuations over repeated images (exposures to the same voltage). At 24 kV, other patterns emerged, with individual remedies showing higher or lower image parameters compared with other remedies and the solvent controls.

Conclusions: GDV technology may provide an electromagnetic probe into the properties of homeopathic remedies as distinguished from solvent controls. However, the present findings also highlight the need for additional research to evaluate factors that may affect reproducibility of results.

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INTRODUCTION

Homeopathy is a 200-year-old system of complementary and alternative medicine (CAM) used worldwide (Jacobs et al., 1998; Kaul, 1996; Merrell and Shalts, 2002). Although there are many schools of clinical thought in terms of how to select and administer homeopathic medicines (remedies), the preparation of the medicines themselves is generally standardized and detailed in references such as the *Homeopathic Pharmacopoeia of the United States.* This field of CAM has stimulated much debate over its validity as a clinical intervention, in part because of the controversial nature of its medicines (Vandenbroucke, 1997; Vandenbroucke and de Craen, 2001).

Preparation of homeopathic medicines begins with selection of a specific animal, mineral, or plant substance, which is then alcohol-extracted, dissolved, and/or crushed with lactose (milk sugar) (Ullman, 2002). The resultant material undergoes a process of serial dilutions in particular ratios (e.g., 1/10, 1/100, or 1/50,000 of source material to distilled water solvent) and multiple succussions (vigorous shaking). Most homeopathic medicines include alcohol (ethanol) in the water as a stabilizer for longer shelf life. The final solution is often poured or sprayed over lactose or lactose/sucrose pellets, which are then dried and packaged in small vials commercially for transport and ease of use. It is also common for clinicians to recommend dissolving the pellets in water and administering the water solution in daily teaspoon or tablespoon doses for therapeutic benefit, especially in hypersensitive patients or those taking conventional drugs that might otherwise slow remedy response (De Schepper, 1999).

Skeptics point out that doses (potencies) greater than 12c (10^{-24} dilution factor) have no molecules of the original source material remaining in the solvent (Avogadro's number is 6×10^{-23}). They therefore theorize that any clinical, animal, or *in vitro* observations suggesting an effect of homeopathy beyond those of an inert placebo could not occur as a result of the agent's capacity to exert specific drug–receptor effects (Moerman and Jonas, 2002; Vandenbroucke, 1997; Walach and Jonas, 2002). Homeopaths, on the other hand, consider the higher potencies beyond Avogadro's number to exert stronger and longer lasting effects than do lower potencies. Hundreds of published case reports in homeopathic journals and books claim short-term and long-term therapeutic benefits for mental, emotional, and physical pathology from treatment with high potencies of specific remedies (e.g., collected homeopathic reference sources from www.kenthomeopathic.com or www.wholehealthnow.com).

Apart from theory or clinical anecdotes, the empirical data on animal, cellular, plant, and *in vitro* preparations indicate that homeopathic remedies in ultramolecular dilutions can exert measurable effects on biologic systems and subsystems (Bellavite and Signorini, 2002; Endler and Schulte, 1994; Jonas et al., 2001; Ruiz et al., 1999; Ruiz-Vega et al., 2000; Schulte and Endler, 1998; Sukul et al., 2000; Sukul et al., 1986, 1999; van Wijk and Wiegant, 1994). Some preclinical studies also support the hypothesis that higher potencies exert effects for longer periods of time than do lower potencies (Sukul et al., 1986). Current models for the nature of remedies largely focus on the possibility of persistent structural modifications in the solvent's molecular organization (e.g., a form of water clusters) (Anick, 1999; Bellavite and Signorini, 2002). One calorimetric study provided indirect evidence supporting a water cluster theory. That is, mixing a 12c remedy preparation (involving both dilution and succussion) with a basic solution released significantly more heat (i.e., presumably disrupting order in the test solution) than with a diluted control solution (Elia and Niccoli, 1999).

Despite some positive, even multicenter, studies (Belon et al., 1999; Schulte and Endler, 1998), clinical and preclinical research in homeopathy has been hampered by inconsistent results and problems in reproducibility (Bellavite and Signoini, 2002; Linde et al., 1994, 1997; Walach, 2000; Walach and Jonas, 2002). Efforts to demonstrate unique signals from homeopathic remedies using methods well-known in conventional physical science (e.g., nuclear magnetic resonance [NMR], infrared, or Raman spectroscopy), also result in variability from ex-

periment to experiment (Aabel et al., 2001; Bellavite and Signorini, 2002; Milgrom et al., 2001). Thus, it is becoming increasingly important to look for novel but objective methods that may advance understanding of the nature of homeopathic medicines, including possible reasons for outcome variability.

Recently, Korotkov and Kovotkin (2001) and others in Russia have developed a computerized image processing technique as an objective biophysical method to measure replicable evidence of internal status and/or subtle energies in living organisms and various liquids, including homeopathic remedies (Jerman et al., 1999). The technique, termed gas discharge visualization (GDV), is a means of characterizing the nonlinear gas discharge image formation around objects subjected to a brief, strong electromagnetic field. GDV reportedly measures phenomena similar to those of Kirlian photography, but offers quantitative advantages over the more limited and variable qualitative assessment possible with the original Kirlian technique.

Previous studies have shown that GDV can differentiate reliably between drops of different electrolyte solutions (sodium or potassium alkali) and distilled water (Korotkov and Korotkin, 2001) or between ultramolecular homeopathic potencies of potassium iodide and distilled water (Jerman et al., 1999). Moreover, homeopathy also falls into the broad CAM category of "energy medicine," an area in which electromagnetic energies may modulate or interact with healing signals (Oschman, 2000). If so, then the effects of the GDV electrical impulses themselves during the measurement process might provide a probe into the properties of homeopathic remedies. The purpose of the present study was to replicate and extend prior GDV research by (1) comparing ultramolecular 30c potencies of three commercially prepared homeopathic remedies widely used in clinical practice (from mineral, plant, and animal sources) with alcohol-water solvent controls and (2) examining the effects of exposure of each homeopathic remedy sample to repeated electromagnetic impulses as part of the GDV measurement process.

METHODS AND MATERIALS

Materials

A Food and Drug Administration-regulated homeopathic pharmacy (Hahnemann Laboratories, San Rafael, CA) prepared split samples of five different test solutions in 16 ounce, amber-colored bottles (total, 10 bottles). Four of the solutions derived from five #35 lactose/sucrose pellets (ratio of sugars, respectively, 20%/80% ± 10%) dissolved in a 20% alcohol (ethanol in glass bottles, from AAPER Alcohol, Shelbyville, KY)-distilled water solution (water prepared on site at Hahnemann Laboratories with a glass still [Barenstead]). The three solutions (total, 6 bottles) that contained the dissolved remedy-treated pellets were Natrum muriaticum (mineral: sodium chloride) 30c, Pulsatilla (plant: windflower) 30c, and Lachesis (animal: Bushmaster snake venom) 30c. The fourth solution contained only dissolved plain lactose/sucrose pellets without remedy, shaken briefly but not succussed after the pellets dissolved. The fifth solution consisted of untreated, unsuccussed 20% alcohol-distilled water solvent alone. Of note, a given 30c remedy potency dose is diluted at $(1/100)^{30}$ or 10^{-60} and succussed 30×20 or 600 times during the manufacturing process. Succussions for remedy preparation are performed with a semiautomated mechanical system that mimics hand succussions but standardizes each stroke (www.Hahnemannlabs.com/preparation.html).

All bottles were uniquely number coded and shipped together by overnight courier in the same box to the University of Arizona with no information other than the numbers as to specific bottle contents. Until the code was broken, Hahnemann Laboratories maintained, at their site, the code list matching remedy types to their original bottle numbers. At the university, a research assistant not involved in obtaining the GDV images split the contents of each of the 10 bottles (using 5-mL latex-free Terumo [Somerset, NJ] syringes) between two new 60-mL amber-colored bottles with 33-mm polyseal black caps (E.D. Luce, Signal Hill, CA), labeled each bottle with a new, unique 3-digit random number code (total bottles, 20), and randomized the order of the bottles for testing.

The unique random numbers identifying each of the 20 test bottles were generated using a random number table (Myers and Hansen, 1993). Bottles were then assigned a sequential slot (1–20) as ordered by the value of their randomly assigned number. This series was then rerandomized a second time to establish the actual order in which the bottles would be tested, using www.randomizer.org. This procedure thus generated 4 bottles each of 5 different agents (Natrum muriaticum, Pulsatilla, Lachesis, Solvent with plain pellets, Solvent alone without pellets) and enabled bottle order randomization and blinding of members of the university research team throughout data acquisition and processing. The GDV model used in these experiments was manufactured in late 1998 from Kirlionics Technologies International, St. Petersburg, Russia (www.gdvonline.com). The research assistant who operated the GDV had received prior in-person instruction from the equipment's developer, Dr. Korotkov.

Procedures

Technical details of GDV image acquisition are documented in previous publications (Bundzen et al., 2002; Korotkov and Korotkin, 2001). Briefly, the equipment sends a standardized brief high-voltage, high-frequency electrical impulse to a drop of liquid to generate a two-dimensional gas discharge image whose characteristics reveal information about the properties of the test solution. The drop hangs 3 mm above the top surface of an optical glass plate. Below the plate, the equipment's optical system uses a charge coupled device camera and digitizes the image data using a videoblaster for analysis with a personal computer using GDV proprietary software. Each train has a duration 0.5 seconds of triangle 10 ms electrical impulses of specific amplitude (range 1, 13.4 kV; range 2, 15 kV; range 3, 17 kV; range 4, 24 kV), steep rate 10^6 V/s, and repetition frequency of 10^3 Hz. The train is applied to the metal grid at the bottom surface of the glass plate, generating an electromagnetic field around each drop. The resultant data represent a burst of electron-ion emission and optical radiation light quanta in the visual and ultraviolet range.

In the present study, one research assistant took all of the GDV images and cleaned the raw data for electrode artifact from all bottles before the identifying number codes were broken for final statistical analysis. The process was done in the same off-campus laboratory room at an average room temperature of 66.3°F, between November 2001 and January 2002. The GDV was allowed to warm up for 15 minutes prior to taking the first images in a given session.

GDV testing involved taking a series of 10 successive images of each of 10 drops per bottle of each test solution ($n = 40$ drops per test solution) at a given electrical impulse range. The drops of solution (average 0.024 mL per drop) hung suspended from an initially filled 1-mL latex-free syringe (Exelint International, Los Angeles, CA) used specifically for liquids analysis in GDV.

A new 1-mL syringe of a given bottle's contents was used to supply the 10 drops for tests at each of the four voltage amplitude ranges (i.e., 4 separate 1-mL syringe samples, supplying 10 drops per syringe per voltage range). The camera lens was wiped with an alcohol prep pad after completion of each set of drops for a given range.

Outcome measures

The image of each drop is called a GDV-gram. Cleaning of the raw data involves visual inspection and removal of pixels from electrode-derived artifact, located distant from the central image in the periphery of the field surrounding the true image. The software utilizes nonlinear mathematical algorithms to process the image after removal of electrode artifact. The primary GDV image parameters analyzed for this study included: form coefficient (fractality), mean image area, and image brightness. Form coefficient assesses the fractality of the outer contour of the image (from chaos theory, a dimension with a noninteger value, a geometric pattern that has similarity at every scale or level of analysis) in the gas discharge process. Notably, chaotic systems exhibit in their dynamics a marked sensitivity to initial conditions that can result in large divergence of findings over repeated measurements. Area

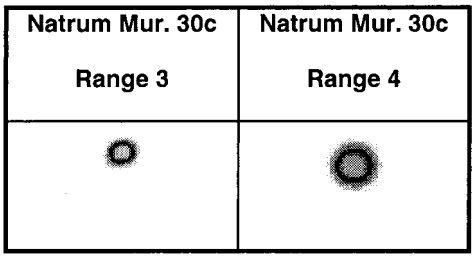


FIG. 1. Average gas discharge visualization (GDV)-Gram Images for 30 c of Natrum muriaticum (Natrum Mur.) from GDV at voltage ranges 3 and 4.

is the total number of pixels in the GDV-gram. Brightness measures the intensity of light in the GDV-gram. Korotkov and Korotkin (2001) previously reported that form coefficient was the GDV image parameter with the best stability and sensitivity across different concentrations of inorganic solutes in distilled water solution.

Statistical analysis

The data were analyzed for each image parameter separately at each voltage range using general linear models for repeated measures, oneway analyses of variance with Tukey *post hoc* analyses (significance at $p < 0.05$), and Pearson correlation coefficients (significance at $p < 0.001$ to correct for multiple comparisons).

RESULTS

Inspection of the data revealed that it was not possible to obtain quantifiable images for most drops of any sample at voltage range 1. At range 2, the electrical impulses rarely generated measurable parameters for the GDV-grams, with 90% of images over all test solutions having parameter values for form coefficient of 0. At range 3, approximately half of the images over all drops generated form coefficient values of 0 and half gave values greater than 0 during the procedure. At range 4, all drops generated quantifiable image parameters greater than 0. Two outliers with extremely high values for a given image of a single drop were eliminated from individual analyses. These outliers were one image for Natrum Muriaticum and one image for Solvent only form coefficient, at range 3.

The data below reflect findings at ranges 3 (including the images with 0 as specific values) and 4. Figure 1 illustrates representative GDV-grams, averaged over samples from all 40 drops of Natrum Muriaticum 30c at range 3 and 4.

General linear models for repeated measures compared the image parameter patterns of the five test solutions over the 10 successive images (using means for the $n = 40$ drops per test solution). Figures 2 and 3, respectively, show the

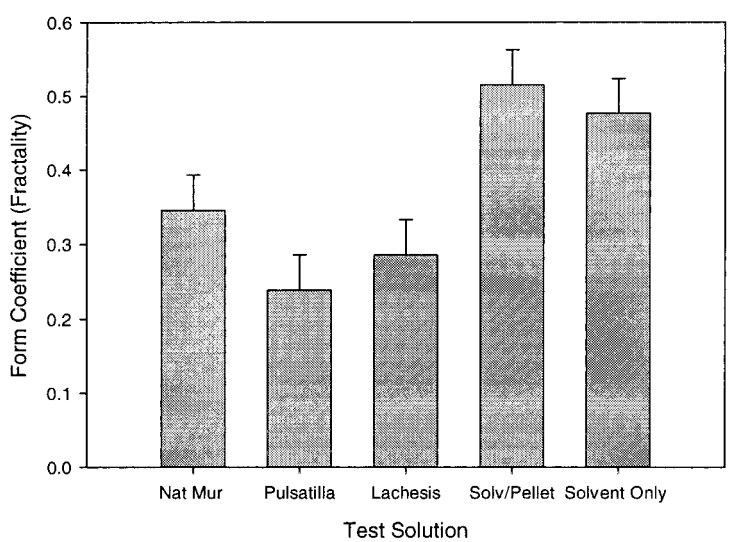


FIG. 2. Voltage range 3 gas discharge visualizations (GDVs) form coefficients over five test solutions (mean ± standard error). Nat Mur, Natrum muriaticum; Solv, solvent.

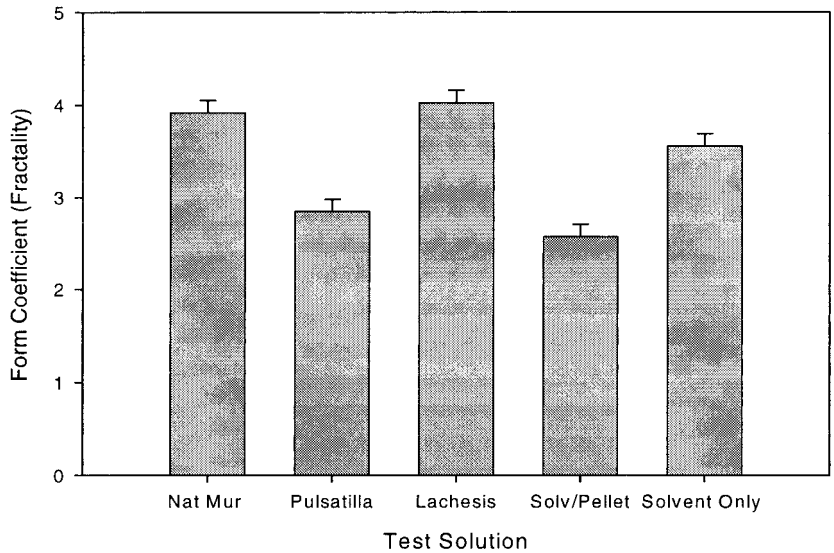


FIG. 3. Voltage range 4 gas discharge visualizations (GDVs) form coefficients over five test solutions (mean ± standard error). Nat Mur, Natrum muriaticum; Solv, solvent.

form coefficient mean values and standard error for each test solution at ranges 3 and 4. Main effects for test solution type were significant (range 3: $F(4,194) = 6.6$, $p < 0.001$; range 4: $F(4,195) = 24.8$, $p = 0.001$). At range 3, the *post hoc* tests revealed that both Pulsatilla and Lachesis were significantly lower for form coefficient than were both Solvent with pellet and Solvent only controls (all $p < 0.05$); Natrum muriaticum showed a similar trend toward a lower form coefficient compared to the Solvent with pellet ($p = 0.08$). At range 4, the *post hoc* tests demonstrated that Pulsatilla was significantly lower for form coefficient than were Natrum muriaticum, Lachesis, and Solvent only ($p < 0.05$); both Natrum muriaticum and Lachesis were significantly higher than Solvent with pellet control ($p < 0.05$).

The pattern of findings was similar for the other two image parameters (Tables 1 and 2).

In addition to main effects, range 3 (but not range 4) showed a significant two-way interaction between test solution type and image number over the 10 repeated exposures to the same voltage for form coefficient (Wilks λ: $F(36,699) = 1.7, p = 0.005$), image area (Wilks λ: $F(36,703) = 1.5$, $p < 0.03$), and brightness (Wilks λ: $F(36,703) = 1.8, p = 0.002$). Figure 4A, 4B, and 4C illustrates the patterns underlying these interactions of the test solutions with repeated image (range 3 voltage exposures) for form coefficient, area, and brightness. That is, the remedies had lower parameter values that overall drifted upward towards those of the solvents by image 10. In addition, the remedies appeared to show oscillatory shifts in values

TABLE 1. RANGE 3 GDV IMAGE AREA AND BRIGHTNESS OVER FIVE TEST SOLUTIONS

	Natrum muriaticum mean	*Natrum muriaticum SE*	*Pulsatilla mean*	*Pulsatilla SE*	*Lachesis mean*	*Lachesis SE*	*Solvent pellet mean*	*Solvent/ pellet SE*	*Solvent only mean*	*Solvent only SE*
Area[a]	167.12	26.66	127.70	26.66	157.31	26.66	269.47	26.66	255.69	26.66
Brightness[b]	89.59	11.92	60.90	11.92	71.91	11.92	125.80	11.92	122.90	11.92

[a]Main effect for area at range 3: $F(4,195) = 5.6$, $p < 0.001$. Significant *post hoc* tests ($p < 0.05$): Pulsatilla < Solvent with pellet and Solvent only; Lachesis < Solvent with pellet. Trends ($p < 0.10$): Natrum muriaticum < Solvent with pellet; Lachesis < Solvent-only.

[b]Main effect for brightness at range 3: $F(4,195) = 6.1$, $p < 0.001$. Significant *post hoc* tests ($p < 0.05$): Pulsatilla and Lachesis < Solvent with pellet and Solvent only.

GDV, gas discharge visualization; SE, standard error.

TABLE 2. RANGE 4 GDV IMAGE AREA AND BRIGHTNESS AT VOLTAGE OVER FIVE TEST SOLUTIONS

	Natrum muriaticum mean	*Natrum muriaticum SE*	*Pulsatilla mean*	*Pulsatilla SE*	*Lachesis mean*	*Lachesis SE*	*Solvent pellet mean*	*Solvent/ pellet SE*	*Solvent only mean*	*Solvent only SE*
Area[a]	5140.36	174.90	3898.21	174.90	5395.65	174.90	3535.69	174.90	4642.00	174.90
Brightness[b]	183.77	0.24	184.16	0.24	183.56	0.24	183.60	0.24	184.12	0.24

[a]Main effect for area at range 4: $F(4,195) = 20.6$, $p < 0.001$. Significant *post hoc* tests ($p < 0.05$): Natrum muriaticum > Pulsatilla and solvent with pellet; Pulsatilla < Natrum muriaticum, Lachesis, and solvent only; Lachesis > Pulsatilla, Solvent with pellet, and solvent only; solvent with pellet < solvent only.

[b]No main effect for brightness at range 4

GDV, gas discharge visualization; SE, standard error.

from one image to the next, whereas the solvents appeared similar in values to one another and relatively unchanging over repeated images.

To evaluate statistically the degree of fluctuation in a given parameter from the effects of the electrical impulses over repeated images of the same sample at range 3, difference scores were calculated from image 1 to 2, 2 to 3, 3 to 4, and so on (through image 9 to 10), using means for the 40 total drops of each test solution. The absolute values of these averaged difference scores were compared with oneway analyses of variance using the five test solutions (Natrum muriaticum, Pulsatilla, Lachesis, Solvent with lactose/sucrose pellets, Solvent only averaged over the 4 bottles per solution) as the grouping variable. The test solutions differed significantly overall on the absolute values of the difference scores between successive images for form coefficient ($F(4,195) = 5.3$, $p < 0.001$), area ($F(4,195) = 2.7$, $p = 0.03$), and brightness ($F(4,195) = 5.1$, $p = 0.001$). *Post hoc* tests revealed that the Lachesis fluctuations were significantly larger in absolute magnitude than those of the Solvent with pellet control solution for form coefficient ($p < 0.001$), area ($p = 0.016$), and brightness ($p < 0.001$). The Lachesis fluctuations were also significantly greater than those of the Solvent only control for both form coefficient ($p = 0.008$) and image brightness ($p = 0.007$).

Korotkov's group (Korotkov and Korotkin, 2001) previously reported that their findings on electrolyte solutions became "unstable" after 5 successive images of the same drop, but no specific quantitative data were shown to support this conclusion. To determine the evolution of effects from performing 10 repeated observations of the same samples at range 3 voltage, the Pearson correlation coefficients between mean values for image 1 of each of the test solutions ($n = 40$ drops, i.e., 10 drops per bottle and 4 bottles per test solution) and the respective findings for subsequent images 2 to 10 for each parameter were calculated. Tables 3A to 3E summarize the correlation findings for image parameters by type of test solution. To limit Type I error, only $p \leq 0.001$ was taken as significant for these analyses. Overall, the findings suggest that the highest correlations between successive images for the remedies occurred primarily for images 1 and 2, with a decay in the magnitude of the correlation thereafter. The remedy with the highest correlations over images was Natrum muriaticum, an observation consistent with the clinical expectation that a mineral-derived medicine would be simpler and more stable than those derived from complex components of living sources (plant or animal). In contrast, the two solvent control solutions maintained large magnitude correlations over the 10 repeated images.

Given the apparent differences in image data between test solutions over repeated voltage exposures, the data above add complexity to evaluating the comparisons between the averages for the 4 split samples of the 5 test solutions. One-way analyses of variance comparing the 4 bottles of the same test substance (each "bottle" representing the average of the 10 successive images over each of 10 drops per bottle) showed that the bottles differed significantly from one another overall on all 3 image parameters at range 3 within Natrum muriaticum (all $p < 0.001$), Lachesis (all $p < 0.03$),

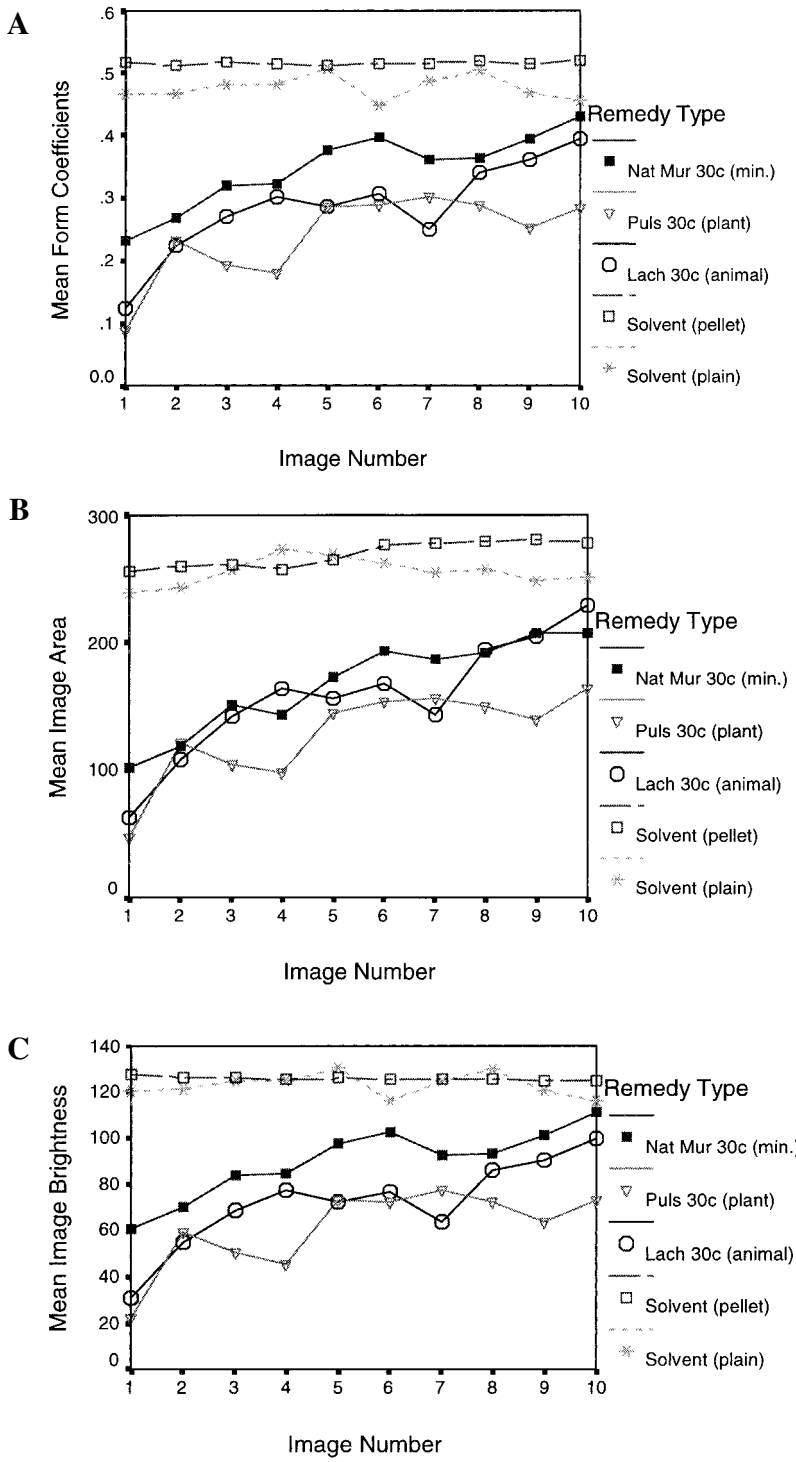


FIG. 4A. Voltage range 3 gas discharge visualization (GDV) pattern of form coefficient values over repeated images of the same drops. The GDV mean form coefficients (fractality) are averaged over 40 drops/test solution. **B.** Voltage range 3 GDV pattern of image area values over repeated images of the same drops. The GDV mean image area is averaged over 40 drops/test solution. **C.** Voltage range 3 GDV pattern of image brightness values over repeated images of the same drops. The GDV mean image brightness is averaged over four split samples/substance (10 drops/split sample = 40 drops/substance). Nat Mur, Natrum muriaticum; Puls, Pulsatilla, Lach, Lachesis.

TABLE 3A. CORRELATION COEFFICIENTS BETWEEN IMAGE 1 AND SUCCESSIVE IMAGES 2–10 FOR EACH PARAMETER OF NATRUM MURIATICUM AT RANGE 3

	Image 2	*Image 3*	*Image 4*	*Image 5*	*Image 6*	*Image 7*	*Image 8*	*Image 9*	*Image 10*
Form coefficient	0.89*	0.67*	0.78*	0.55*	0.53*	0.69*	0.70*	0.62*	0.58*
Area	0.90*	0.61*	0.77*	0.55*	0.56*	0.64*	0.62*	0.65*	0.48*
Brightness	0.89*	0.67*	0.76*	0.56*	0.53*	0.70*	0.71*	0.63*	0.58*

*$p < 0.001$.

TABLE 3B. CORRELATION COEFFICIENTS BETWEEN IMAGE 1 AND SUCCESSIVE IMAGES 2–10 FOR EACH PARAMETER OF *PULSATILLA* AT RANGE 3

	Image 2	*Image 3*	*Image 4*	*Image 5*	*Image 6*	*Image 7*	*Image 8*	*Image 9*	*Image 10*
Form coefficient	0.54*	0.44**	0.31	0.45**	0.49*	0.28	0.12	0.51*	0.41**
Area	0.59*	0.42**	0.35	0.49**	0.52*	0.33	0.11	0.52*	0.49**
Brightness	0.54*	0.44**	0.30	0.47**	0.46**	0.29	0.16	0.52*	0.47**

*$p < 0.001$; **$p < 0.01$

TABLE 3C. CORRELATION COEFFICIENTS BETWEEN IMAGE 1 AND SUCCESSIVE IMAGES 2–10 FOR EACH PARAMETER OF *LACHESIS* AT RANGE 3

	Image 2	*Image 3*	*Image 4*	*Image 5*	*Image 6*	*Image 7*	*Image 8*	*Image 9*	*Image 10*
Form coefficient	0.41**	0.46**	0.42**	0.32**	0.12	0.22	0.09	0.21	0.16
Area	0.52*	0.47**	0.46**	0.39	0.16	0.26	0.16	0.26	0.16
Brightness	0.43**	0.48**	0.42**	0.30	0.15	0.22	0.10	0.21	0.17

*$p < 0.001$; **$p < 0.01$

TABLE 3D. CORRELATION COEFFICIENTS BETWEEN IMAGE 1 AND SUCCESSIVE IMAGES 2–10 FOR EACH PARAMETER OF SOLVENT WITH LACTOSE/SUCROSE PELLETS AT RANGE 3

	Image 2	*Image 3*	*Image 4*	*Image 5*	*Image 6*	*Image 7*	*Image 8*	*Image 9*	*Image 10*
Form coefficient	0.997*	0.996*	0.995*	0.996*	0.995*	0.995*	0.996*	0.995*	0.995*
Area	0.971*	0.969*	0.957*	0.967*	0.995*	0.926*	0.922*	0.934*	0.905*
Brightness	0.996*	0.996*	0.994*	0.996*	0.996*	0.996*	0.996*	0.994*	0.995*

*$p < 0.001$

TABLE 3E. CORRELATION COEFFICIENTS BETWEEN IMAGE 1 AND SUCCESSIVE IMAGES 2–10 FOR EACH PARAMETER OF SOLVENT ONLY AT RANGE 3

	Image 2	*Image 3*	*Image 4*	*Image 5*	*Image 6*	*Image 7*	*Image 8*	*Image 9*	*Image 10*
Form coefficient	0.87*	0.72*	0.73*	0.77*	0.85*	0.72*	0.90*	0.78*	0.84*
Area	0.83*	0.72*	0.69*	0.69*	0.71*	0.64*	0.87*	0.76*	0.79*
Brightness	0.88*	0.73*	0.73*	0.78*	0.84*	0.73*	0.89*	0.79*	0.84*

*$p < 0.001$

Solvent with pellet (all $p < 0.001$), and Solvent only (all $p < 0.001$), but not within Pulsatilla. At range 4, bottles of Natrum muriaticum ($p < 0.001$ for form coefficient and area), Pulsatilla ($p < 0.01$ for all 3 parameters), Solvent with pellet ($p < 0.05$ for all 3 parameters), and Solvent only ($p < 0.05$ for area and brightness) differed significantly from one another within each test substance on some image parameters; while Lachesis exhibited significant differences between its four bottles only for form coefficient ($p < 0.05$).

DISCUSSION

The findings suggest that the biophysical method of GDV may allow differentiation of ultramolecular doses of homeopathic remedies from solvent controls and perhaps from each other at specific voltage amplitudes under blinded conditions. The 30c potencies were far beyond Avogadro's number, making it highly improbable that any molecules of the original source materials from the remedies persisted in solution. The test solutions containing the three remedies (originally prepared by spraying over the lactose/sucrose pellets) and the solvent with untreated lactose/sucrose pellets all had the same physical material present (i.e., a 20% alcohol-distilled water mixture containing five dissolved #35 size lactose/sucrose pellets).

The pattern of the data suggests that the original presence of the different remedies on the pellets at range 3 altered the ability of the GDV to generate an image from the drops as compared with the Solvent with pellet control solution. Moreover, analogous to the greater clinical instability or lability of the two nonmineral remedies (Morrison, 1993), repeated exposure to the range 3 voltage disrupted the correlation between the first and subsequent images the most for the animal and plant-derived remedies as compared with the mineral remedy or solvent controls. At the highest voltage (range 4), the pattern of the main effects for the image parameters diverged from that at range 3. Nonetheless, each remedy at range 4 differed from at least one of the solvent control solutions. Taken together, the findings indicate that both the voltage level and the repetition of a given voltage used to generate the GDV-grams exert an influence on the resultant image characteristics. It may be useful in future studies to examine further the effects of different durations, waveforms, and amplitudes of the applied voltage in a wider variety of remedies and potencies, as well as types of solvents.

Varying the ratio of alcohol to water in the solvent may also modify the ability of GDV to generate images from homeopathic remedies because some researchers have found that certain remedies prepared in an ethanol-water mixture, but not those in pure water or pure alcohol, have biologic effects in animals (Sukul et al., 1999). Unpublished data in our laboratory (D.L.) suggest that it has not been possible to obtain GDV-grams from 100% alcohol solutions. From a materials science perspective, prior research has demonstrated that liquids, including alcohol-water mixtures (Dixit et al., 2002) and certain dilute solutions (Samal and Geckeler, 2001; Sobott et al., 1999; Tu and Laaksonen, 2000), are nonhomogeneous (i.e., incompletely mixed) in the distribution and organization of their constituent molecules.

A number of contemporary homeopathic investigators have proposed that the original presence of the source molecules from a remedy seeds the formation of some type of water clusters (e.g., clathrates, cage-like structures of solvent around solute molecules [Bellavite and Signorini, 2002] or zwitterions [Anick, 1999]). These hypothesized water clusters, not the original source molecules, then carry the relevant information through successive dilutions and succussions. Consistent with the possibility of water cluster formation from serial dilution and shaking, Lo (Lo, 1996; Lo et al., 1996) has reported the ability to form stable crystalline water clusters at room temperature, seeded into unique structures by original source materials such as sodium chloride or monosodium phosphate, using a proprietary method that others have not as yet replicated independently. The order could arise, alternatively, as has been postulated (Arani et al., 1995; Bellavite and Signorini, 2002; Del Giudice et al., 1988; Del Giudice and Preparata, 1994) from coherent electromagnetic fields organized within the solvent. The present findings are potentially consistent with a solvent-related phenomenon that is disrupted in its organization, as revealed by excess heat release from mixing

with acidic or alkaline solutions (Elia and Nicoli, 1999) or, in this case, from GDV-generated electromagnetic impulses. In parallel, many clinicians claim that intense heat or strong magnetic fields such as those from magnetic resonance imaging also can inactivate homeopathic medicines.

Although trace contamination from glass or plastic is possible, it is unlikely that the data reflect solely a contaminant effect. If the glass bottles or latex-free plastic syringes introduced trace amounts of silicates or other chemical artifacts into the solutions (Milgrom et al., 2001), all of the solutions, including the remedies and the solvent controls, should have acquired comparable levels of such contaminants and therefore exhibited similar findings at both ranges 3 and 4. Some researchers have also expressed concern that the succussion process per se releases artifacts such as ions from glass tubes or free radicals during the original preparation of the remedies. The placebo pellets dissolved in the present solvent control bottles were not prepared by spraying succussed, remedy-free solvent on them. Thus, an appropriate additional control condition for future studies should be solutions in which placebo pellets that had been originally treated with succussed, remedy-free solvent and then dried, are dissolved. The latter would then control for succussion per se as a factor in generating GDV differences between solutions containing specific remedy-treated pellets and those containing remedy-free placebo pellets.

The bottles were run in randomized order by the same blinded research assistant (presumably generating comparable intentionality toward each bottle) in the same physical setting (presumably exposed to similar ambient low level electromagnetic environmental contaminants). Although blinding, randomization, and procedural standardization should have protected the findings from systematic bias, it may still be necessary to carry out direct measurement of experimenter intentionality and expectation (Tiller, 2000; Tiller et al., 2001), ambient electromagnetic fields, and gas chromatographic analyses of the test solutions to minimize possible confounds in the implementation of the study. Such measures may assist in evaluating factors that have hindered replication in other types of homeopathic research. In the present study, all data acquisition and cleaning were completed before the blind was broken. However, given the need for the most stringent methodological rigor in homeopathic studies, researchers should perform even the final statistical analyses blindly, using only bottle numbers, before breaking the codes to identify their contents in future GDV investigations.

Within the present study, the variability from bottle to bottle raises some questions. Previous GDV studies on human subjects and on nonhomeopathic materials such as distilled water and ordinary dilutions of electrolytes in distilled water, including sodium chloride, reported good reliability, at least over images 1–5 (Korotkov and Korotkin, 2001). However, the prior research did not use the same solvent as in this study or statistically compare values for repeated images in split samples. Here, despite differences between bottles of the same sample solutions starting at image 1, the averaged data over the 40 drops per test solution exhibit nonrandom patterns distinguishing the remedy solutions from the solvent controls. Heterogeneity in distribution of solvent-dependent water clusters among the bottles could contribute to the split sample variability. Korotkov's papers suggest that it is necessary to use 40 data points for statistical accuracy, a dataset available in the present study using the 10 drops per bottle over the 4 bottles per test solution. The initial pellet form of the homeopathic remedies and the alcohol-water mixture rather than plain distilled water solvent were chosen to reflect the nature of materials common in clinical practice.

Thus, the current data showing asynchrony in the development of a measurable response signal and the emergence of drop instability over repeated measurements made it difficult to perform a conventional split sample analysis at a fixed point in the image acquisition or over the 10 successive images taken for each drop at each range. The findings suggest that there may be a threshold voltage impulse for a given sample of homeopathic remedy in a 20% alcohol-water solvent at which the gas discharge occurs. In many senses, the procedure of measuring a GDV-gram over repeated images of liquids has notable parallels to that of visual or auditory evoked potentials in human electroencephalography. That is, the signal-to-

noise ratio may be too weak on any single measurement to detect the response in a reliable manner. However, averaged over repeated assessments during administration of a known stimulus, a specific measurable response becomes evident.

In subsequent GDV research, it will be important to assess reasons for variability between samples of the "same" homeopathic remedies versus dilute solutions prepared without succussion. The nonlinearity of the optical discharge process in GDV, especially over repeated images, may provide a starting point. Certain types of nonlinearity, notably chaotic processes, are highly sensitive to minor variations in initial conditions, leading to dramatic divergence of outcomes over time (Bell et al., 2002; Bellavite and Signorini, 2002). As we have pointed out in an earlier paper (Bell et al., 2002), nonlinearity of the measured signal also could contribute to apparent failures of replication in homeopathic research. A recent clinical study using homeopathically prepared dust mite in the treatment of patients with asthma demonstrated oscillatory patterns with active remedy, but not placebo, consistent with remedy-induced shifts in nonlinear dynamics of the patients (Hyland and Lewith, 2002; Lewith et al., 2002). Another potential factor may be hormesis, the bidirectional or oscillatory property of the dose-response curve of many different agents at low doses (Calabrese and Baldwin, 2000). Clarification of these issues may advance understanding of how to replicate research on homeopathic medicines in preclinical and clinical studies.

It is unclear whether or not this GDV technique will permit distinguishing different remedies or different potencies of the same remedy from one another. In the present study, the three remedies overlapped with each other for a given parameter. However, the various oscillatory patterns of change in multiple parameters under the range 3 stimulus of the repeated electrical impulses for image acquisition may provide a direction for additional research. For instance, would a combination of image qualities provide a GDV "fingerprint" for a specific remedy? Nonparametric multivariate statistical methods such as grade-of-membership analyses might permit determination of the degree to which a given agent belongs in a particular therapeutic group as opposed to another (Davidson et al., 2001). As a starting point for further testing, some homeopaths have identified clinical similarities among remedies drawn from the same taxonomic kingdom, class, family, or species (e.g., different snake venoms [Lachesis, *Crotalus horridus, Elaps corallinus*] or certain plants [*Umbelliferae* group or *Compositae* group]). Perhaps, however, GDV might be able to differentiate not between different remedies, but simply various potencies (e.g., indicative of the amount of subtle energy available in a 200 c as opposed to a 30 c or a 6 c potency). Notably, Jerman et al. (Jerman et al., 1999) reported that GDV could distinguish between solutions of a given homeopathic remedy at a given potency and those of the same substance diluted to a comparable degree but not succussed like a remedy.

In summary, GDV may offer a useful tool to understand better the nature of homeopathic medicines and their potential effects on dynamical living systems (Schwartz et al., 2000). GDV may provide a means for distinguishing between solvents with active homeopathic remedies (but containing no molecules of the original source materials) and untreated solvent controls. However, in view of past replication difficulties in many forms of homeopathic research, it will be essential for multiple laboratories in multicenter studies to replicate and extend these GDV investigations. It will also be important for collaborating laboratories with different analytical tools to assess the same test solutions, test for contaminants, and evaluate the correlations between their findings (e.g., with GDV, calorimetric heat release, and nuclear magnetic resonance [NMR] spectroscopy).

The uncertainty of outcomes in homeopathic research is a fundamental problem for the field in general. In order to know if, when, and how homeopathy may help a given patient, it is ultimately important to understand better how properties of the medicines could effect shifts in health. If standardized, GDV testing in the clinical setting might eventually allow differentiation of active from inactive remedy supplies at the time of administration to patients. The ability of GDV to assess both liquids and human subjects (testing fingers or toes) could facilitate studies in which both the individually chosen remedy and the patient undergo testing

at baseline and follow-up to determine any objective, measurable characteristics that might predict better or worse clinical outcomes. Correlations with other physical and/or psychophysiologic measurements may also clarify these types of effects (Kiang et al., 2002; Ruiz et al., 1999; Ruiz-Vega et al., 2000).

It is reasonable to question whether it is appropriate to invest time and resources into research on a new technology such as GDV, about which little is known, in order to study an already highly controversial phenomenon (i.e., homeopathy) in CAM (Levin et al., 1997). Certainly the initial conservative and appropriate approach is to apply to this problem basic science tools whose properties, confounds, and limitations are better documented, e.g., NMR spectroscopy. Work of the latter type is currently underway. At the same time, many clinical claims about homeopathy extend into the CAM area of subtle energy medicine (Oschman, 2000; Russo, et al., 2001). Over the history of science and medicine, the development of new measurement tools with different types and degrees of sensitivity and specificity enabled researchers to detect objects and phenomena about which people had no awareness without these instruments. Consequently, regardless of whether GDV proves itself in the long term to be a reliable tool for quantification of subtle energy properties in living and nonliving systems, it represents a beginning toward addressing the need for research instruments directed at the proposed area of study (i.e., ultramolecular doses of homeopathic remedies and related "subtle energy" phenomena).

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