Journal of Scientific Exploration, Vol. 24, No. 1, pp. 5–39, 2010 0892-3310/10

RESEARCH

Rebuttal to Claimed Refutations of Duncan MacDougall's Experiment on Human Weight Change at the Moment of Death

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The present author would like to dedicate this paper to Dr. Duncan MacDougall.

Abstract—A critical review was conducted on criticisms expressed in books and on websites of Duncan MacDougall's weight measurement experiment upon the death of terminally ill patients; theoretical simulations of MacDougall's experiment using a modern weighing system with load cells and thermohydraulic analysis were employed. The following conclusions were obtained: (1) the uncontrolled escape of moisture from bodies due to insensible perspiration has practically no effect on the conclusion of his experiment that there had been anomalous losses in the weight of his patients upon death; (2) the speculated effect of convection air currents on MacDougall's balance scales does not exist; (3) vibrational disturbances caused by cardiac and breathing activities, which disappear after the death of the patients, have practically no effect if the change in weight upon death is in the tens of grams rather than a few grams; and (4) the speculative tricky role of buoyant force of air on the body can be denied. Therefore, all the cases of his experiment do remain as pioneering cases published in a scientific journal. Theoretical implications of his experimental result and future perspectives of the experimental approach to this subject are discussed.

Keywords: MacDougall experiment—missing weight upon death—skeptical comments—critical review—analytical simulation of experiment—inadequate control—water vapor loss—convection air currents—disturbance of cardiac activity—buoyant force—the law of conservation of energy—psychical knowledge

1. Introduction and Objectives

In 1907, Duncan MacDougall, MD (1867−1920) published the paper "Hypothesis Concerning Soul Substance Together with Experimental

Evidence of the Existence of Soul Substance." Since then, there have been several skeptical as well as critical arguments against his paper written in books and posted on many websites. The present author expressed in a paper recently published in the *Journal of Scientific Exploration* (Ishida, 2009) the following:

Most of these arguments are similar, stating how "his experiment was sloppy; his claimed weight of the soul turned out to be simply the result of sloppy science; his experiment was silly, you'd need not just a scale, but a completely isolated system." From a scientific point of view, it can be shown with relative ease that none of these criticisms have a quantitative basis. . . . Indeed, it will be very difficult to scientifically refute the missing weights in MacDougall's experiment, even though his experiment, conducted around 100 years ago, may appear sloppy from the viewpoint of today's scientific standards. (p. 6)

Because, in the present author's point of view, MacDougall's paper is *scientifically* important, and since no one has ever published critical reviews of the criticisms against MacDougall's paper based upon a scientifically quantitative basis, the objectives of the study presented in this paper are to conduct such a review and provide a sound scientific basis when people talk about MacDougall's experiment. Additionally, theoretical implications of his experimental result and future perspectives of the experimental approach to this subject are discussed.

2. Specific Expressions of Criticism against MacDougall's Experiment

Table 1 shows a summary of MacDougall's experiment based upon his paper (MacDougall, 1907). MacDougall's unaccounted for decrease in the weights of his patients upon death ranges from 10.6 g to 45.8 g. The following seven criticisms have been specifically expressed so far in books and on websites:

(1) *The experiment was inadequately controlled.* Under this category, the following two critical comments exist:

(a) The weight loss during the life-to-death transition caused by insensible perspiration was not controlled because the patients were not in a closed system but in open air. This was one of the points stated by the psychologist Susan Blackmore when stating that "In any case much of this argument is unnecessary for there was too much wrong with his methods" (Blackmore, 1992:204). She also referred to Twining's mouse experiment (Carrington, 1939:243–245) in a closed glass tube to control (i.e. to avoid) the loss of moisture from the experimental

TABLE 1
Summary of MacDougall's Experimental Results for the Unaccounted Losses in the Weight of the Patients upon Death

Patient		Final Unaccounted Loss in Weight		Sudden or in-a-Few-Seconds Loss[a]		
No.	**Description**	**oz**	**g**	**oz**	**g**	**Note[b]**
1	Male/dying of TB	3/4	21.3	3/4	21.3	Suddenly coincident with death the beam end dropped with an audible stroke hitting against the lower limiting bar and remaining there with no rebound. The loss was sudden and large, three-fourths of an ounce in a few seconds. During the 3 h and 40 min prior to death, a loss rate of 1 oz/h was observed due to evaporation of moisture in respiration and evaporation of sweat.
2	Male of totally different temperament from Patient 1/ dying of TB	1.5, 50 grains	45.8	1/2	14.2	Sudden loss of half an ounce, and total loss in 18 min was 1.5 ounces & 50 grains. After this 18 min, no change in 40 min. During 4 h prior to death, 3/4-oz/h loss rate was observed due to evaporation of moisture in respiration and evaporation of sweat.
3	Male/dying of TB	1.5	42.5	1/2	14.2	Sudden loss of half an ounce, and additional loss of one ounce a few minutes later.
4	Female/dying of diabetic coma	Spoiled data		Spoiled data		The scales were not finely adjusted and there was an interference by people opposed to MacDougall's study. Although at death there was an apparent loss of 3/8 to 1/2 ounce, MacDougall regarded this test as of no value.
5	Male/dying of TB	3/8	10.6	3.8	10.6	Sudden and distinct drop in weight of about 3/8 ounce with the beam hitting the lower bar with as great a noise as in the first case, but peculiarly on bringing the beam up again with weights and later removing them the beam did not sink back to stay for fully 15 min.
6	(No description given in the text)	Test failed		Test failed		The patient died almost within 5 min after being placed upon the bed on the scale platform and died while the scale beam was still being adjusted. There was an apparent loss of 1.5 ounces, but the data was uncertain.
Extra	Extra tests on 15 dogs/drugs used to cause quiet death	No loss of weight detected at death		None detected within the sensitivity of the scales		The experiments carried out were surrounded by every precaution to obtain accuracy and the results were uniformly negative; no loss of weight at death. Weight of dogs ranged from 15 to 70 pounds.

Note: TB = tuberculosis.
[a] Sensitivity of the scales was 2/10 of an ounce (5.7 g) for human cases, and 1/16 of an ounce (1.8 g) for dog cases.
[b] One ounce = 28.350 g. One grain = 64.799 mg.

subjects and concluded that Twining was right and MacDougall wrong (Blackmore, 1992:205).

(b) The possible effect of convection currents of air on the weighing scale was not controlled (i.e. not avoided). This was pointed out by the science writer and scientist Len Fisher (2004). As he writes in his book, Fisher apparently acquired this idea of convection currents from a technical paper published by Count Rumford about 200 years ago in a British journal (Thompson, 1799), in which Rumford described his experiments of "weighing the heat" to show that heat is not a substance which exhibits a weight. In his early phase experiments, Rumford obtained a peculiar result which apparently showed that when liquid water (about 266 g) in a Florence flask lost heat after being completely frozen, the apparent weight of the flask *increased* by about 8.68 mg (compared with the wine flask of initially equal weight on the other side of a balance). Repeated experiments showed similar results. Rumford speculated the probable causes of this peculiar result to be (a) convection air currents caused by unequal temperatures between the flasks and ambient air, (b) unequal quantities of moisture attached to the surfaces of the two flasks, or (c) both these causes operating together. He improved his experimental procedure to avoid these probable causes in his later phase experiments, and obtained the unchanged exact balance between the two flasks.[1] Rumford concluded that heat does not exhibit a weight. Fisher took (a) to be a possible explanation for the unaccounted loss of weight upon death in MacDougall's experiment, saying that MacDougall did not allow for the possibility of convection currents occurring when the body cools upon death (Fisher, 2004:18–19).

(2) *MacDougall had not been able to judge the time of death for his patients.* This was also pointed out by Blackmore when stating "he had no way of timing death" (Blackmore, 1992:204). She reasoned this based upon the cases of Patients 2 and 3, who showed a loss of weight in the few seconds after the judgment of time of death, and showed additional loss up to 18 min after the supposed time of death. Hence, she wonders how MacDougall could conclude that the weight was lost at the moment of death (Blackmore, 1992:204).

(3) *MacDougall's fellow doctor Augustus P. Clarke's criticism.* MacDougall failed to take into account the sudden rise in body temperature at death when the blood stops being air-cooled via its circulation through the lungs. Clarke continues:

> . . . the sweating and moisture evaporation caused by this rise in body temperature would account both for the drop in the men's weight and the dogs' failure

to register any decline in weight, as dogs do not have sweat glands, they pant to cool themselves. (Schill, 2009)[2]

(4) *The sample size of the experimental group was far too small and the ability to measure the changes in weight was less than precise.* These two comments were also written together with comment (3) above by Brian Schill (2009)[2].

(5) *There have been other speculations/hypotheses to try to explain scientifically the missing weights.* The following are ones that the present author has encountered:

(a) The dynamic effect of the heart beating, which shows peak-to-peak vibration amplitudes of 1.3–3.0 N (132.6–306.1 gf) depending on the human subject, and appears when the patients are still alive and disappears upon death. If the remarkable dynamic vibration force measured in the experiment of "hemodynamics" (Conforto et al., 2002) is taken into account, the change in heart vibrations before and after death may explain the missing weights. (It should be noted that the authors of Conforto et al. have nothing to do with this speculation.)

(b) If postmortem body swelling of the patients occurred in MacDougall's experiment, the missing weights may be explained by the buoyant force acting on the swollen body.

In Section 3, all of these critical comments against MacDougall's experiment are critically reviewed on a scientifically quantitative basis.

3. Review of Comments Based on a Scientifically Quantitative Basis

Before reviewing the critical comments summarized in Section 2, simplified simulations of MacDougall's experiment were conducted and are discussed in Section 3.1 to give a scientifically quantitative basis for the review. Critical reviews of each comment are given in Section 3.2.

3.1 Simulation of MacDougall's Experiment Using a Modern Weighting System

(1) ***Mathematical model for the weighing system.*** The present author (Ishida, 2009) showed some simulations of MacDougall's type of experiments by using an analytical model for a weighing system with today's technology. The weighing system is the one used by Lewis E. Hollander, Jr., in his weight measurement experiments of sheep upon death (Hollander, 2001). The system consists of a platform (size: 215 × 92 cm) on a steel frame set on four load cells of 45-kg capacity each. According to that paper, the mea-

sured response time of the system was 0.2 s; the full-scale capacity of the system was 100 kg, with a sensitivity of −5 g.

The analytical model used in Ishida (2009) is briefly described here. The basic equation for the damped vibration model of a scale with a mass *m* on it and under an externally applied force is expressed as follows:

$$x'' + 2\sigma x' + \omega_n^2 x = F(t)/m, \tag{1}$$

where

- x = small displacement (in meters) of the mass from its equilibrium position ($x = 0$); x'' and x' are the time derivatives of x, or acceleration and velocity, respectively; the positive direction of x is defined here as vertically downward, along the direction of gravity;
- σ = vibration decay rate (1/s);
- ω (= $k_{eq}/m)^{0.5}$ = natural angular frequency of the system (rad/s);
- k_{eq} = equivalent spring constant of the system (N/m);
- $F(t)$ = time (t) dependent external force applied to the system, expressed as $F_o \times f(t)$ with the dimensionless function f(t) and the normalization force factor F_o (N);
- m = total mass (kg) of the system, which is supposed to be constant throughout the experiment.

The characteristic vibration parameters of the system were determined in Ishida (2009) based upon the experimental paper by Hollander (2001). Hence, only these parameters are shown here:

- σ = 0.138 (1/s);
- k_{eq} = 1.646×10^3 N/m;
- ω_o = $(k_{eq}/M_p)^{0.5} = 4.54$ rad/s = angular frequency of the natural vibration of the system without the experimental subject on the platform; M_p (= 80 kg) is the supposed mass of the system without the experimental subject;
- ω_n = $\omega_o/(1 + m_{sp}/M_p)^{0.5}$ = angular frequency of the natural vibration with the experimental subject on the platform; m_{sp} is the mass of the experimental subject; the total mass, m, of the system becomes $M_p + m_{sp}$.

The mathematical model is intended to predict the small vibrational behavior of the scale with respect to its equilibrium position when acted upon by an external force applied to the system. If there is a small change in the mass m, the effect may be expressed as external force F(t) to simulate the removal or addition of the corresponding load. Here, the physical quantity $k_{eq} \times x(t)$ is denoted as the "system response," which shows the simulation of the following supposed experiments. The linear differential equation (Equation 1) is solved numerically using the Euler–Romberg method (Ishida, 2009).

(2) ***Conditions for parametric simulations of MacDougall's experiment.*** Let us assume that the first case (Patient 1) of MacDougall's experiment is conducted with this weighing system. The following conditions are used for all the simulations:

(a) The nominal weight of the experimental subject (m_{sp}) is assumed to be 62.0 kg, which is not corrected for the buoyant force on the body. It is assumed that the dying patient is lying supine on the platform of the weighing system. (No information on the weight is provided in MacDougall, 1907.) The natural angular frequency of the system with m_{sp} = 62.0 kg is calculated as ω_n = 3.41 rad/s; the corresponding frequency ($f_n = \omega_n/2\pi$) becomes f_n = 0.542 Hz.

(b) Disturbances caused by cardiac activity (a constant heart rate of 64 beats/min, f_{card} = 1.07 Hz) and breathing (13.1 breaths/min, f_{breath} = 0.22 Hz) up to the time of death are accounted for in the external force term F(t) in Equation 1. The heart and breathing rates correspond to values for human adults at rest. The cardiac disturbance is expressed by using the average F_y component of the cardiac activity force (CAF) shown in Figure 1 of Conforto et al. (2002). The breathing disturbance is expressed with a square impulse of −0.1 N·s at the start of inhalation and +0.1 N·s at the turnaround to exhalation; both have impulses with a time width of 0.5 s. These disturbance treatments are generally identical to the situation assumed for the human case in Ishida (2009).

(c) The dying patient on the platform is assumed to be in open air and covered with bed clothing. This corresponds to MacDougall's experimental situation where no control of escaping moisture from the patient's body through "insensible perspiration" was provided. The weight change rate due to insensible perspiration (i.e. evaporation of respiration moisture and sweat) is assumed to be −28.35 g/h before death and half this value after death (−14.2 g/h). The former value is the observed average weight loss rate of Patient 1 during the 3 h and 40 min prior to death; the latter is arbitrarily assumed to account for the possible postmortem evaporation of moisture from the body surface covered with bed clothing.

(d) The observed anomalous weight loss of 21 g (three-fourths of an ounce) upon death is simulated as an instantaneous loss of load upon death and included in the external force term F(t).

The analytical simulations are conducted for the transient time of 20 min, with the time of death arbitrarily assumed to be 120 s into the transient time. The simulations are terminated 18 min after the time of death. The time increment for the numerical solution is constant at about 7 ms, although the Euler–Romberg algorithm automatically cuts down the size until a required convergence criterion is satisfied. The convergence criterion used for a change in solutions (for the dimensionless displacement and velocity) in successive iterations is 10^{-7}, which corresponds to convergence within 0.01% for displacement (x) and less than 0.01% for velocity (x′).

(3) ***Results of parametric simulations.***

(a) *If there is no loss of weight upon death.* Figure 1 shows the simulation results for a case where there is no anomalous weight loss upon death. The figure shows only the initial 200 s. In the calculation, the peak-to-peak amplitude of the CAF is adjusted to 3 N (306.1 gf), which is the maximum range of the F_y component reported in Conforto et al. (2002) (the average F_y component shown in Figure 1 of Conforto et al. has a peak-to-peak amplitude of about 1.62 N; the adjustment is made by multiplying the factor −1.85 with F_y; the minus sign of the multiplier is also arbitrarily selected to maximize the effect of disturbance on the system response in the downward direction).[3] This 3-N value is selected to answer the speculation in Section 2(5)(a). The breathing disturbance contributes about 0.4 N (41 gf) to the total peak-to-peak swing.

In Figure 1, the system response before the supposed time of death ($t < 120$ s) vibrates with a peak-to-peak swing of about 80 gf, which is caused primarily by the breathing disturbance. If only the cardiac disturbance is assumed in the simulation, the swing becomes about 26 gf. The fundamental frequency of the breathing disturbance ($f_{breath} = 0.22$ Hz) assumed in this simulation is much closer to the natural frequency of the weighing system ($f_n = 0.542$ Hz) than the cardiac disturbance ($f_{card} = 1.07$ Hz); also, the cardiac disturbance has higher frequency components with heavier weights than the fundamental frequency. These frequency characteristics explain the effects of the disturbances on the system response. This behavior was discussed in Ishida (2009).

As seen in Figure 1, the sudden disappearance of the large disturbance caused by CAF and breathing upon death leaves damped vibrations in the system response immediately after death. However, the simulation results clearly show that if there is no anomalous loss of weight upon death, the weighing system settles after the cessation of damped vibrations in the expected quasi-steady history of weight decline caused by the uncontrolled escape of moisture.

Because the system response vibrates with such large amplitude (peak-to-peak swing of about 80 gf), how can we assume that the experimental subject initially weighed exactly 62.0 kg,[4] which is the initial condition of the

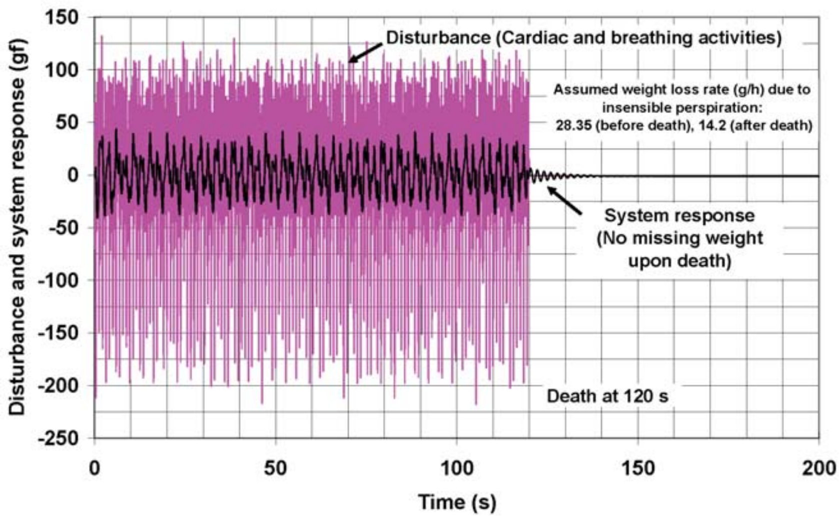

Figure 1. Simulation of MacDougall's experiment with no missing weight (only first 200 s is shown).

experiment for the evaluation of the change in weight upon death? This argument has good scientific basis when considering the limitations in accuracy for measuring the weight of a live human. MacDougall probably did not realize such a problem could exist with his scales. We have to resort to averaging the vibrating system response over a time period (120.0 s) before death to define the initial weight of the experimental subject. In the case shown in Figure 1, the time-averaged system response was +0.254 gf. This value is affected by the weight loss caused by the insensible perspiration. If the weight loss due to insensible perspiration is ignored, the time average becomes +0.726 gf.[5] The calculated weight loss caused by the insensible perspiration from the start to t = 150 s (when the damped vibrations have ceased) is about 1.1 g; hence, a loss of 2 g in the apparent weight during the life-to-death transition can be explained scientifically, although 2 g is below the detection sensitivity (5 g) of the weighing system. This means that if we use a similar type of scales to this weighing system in experiments with human adults and allow uncontrolled moisture to escape, any measured weight loss that may contain some anomalous loss should be more than the 2 g to justify a claim that there is an anomalous loss in the measured data. Even if the escaping moisture is controlled in the experiment, it will be difficult to claim that an anomalous loss is a value less than 1 g because of the disturbances caused by cardiac and breathing activities before death.

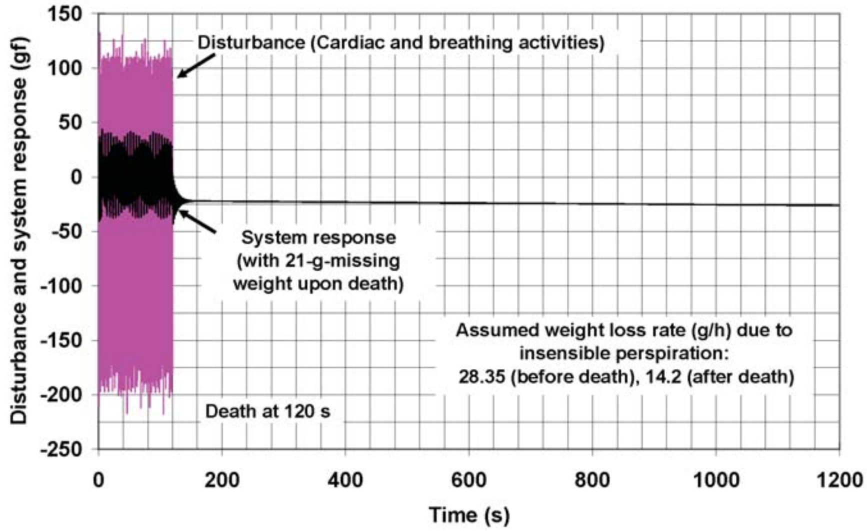

Figure 2A. Simulation of MacDougall's experiment with a missing weight of 21 g.

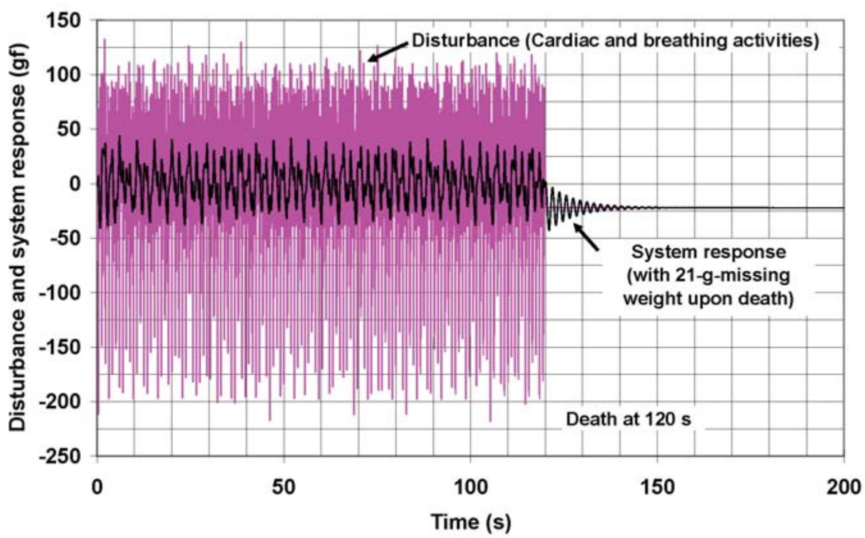

Figure 2B. Representation of the initial 200 s of Figure 2A in an expanded time scale.

(b) *If there is a loss of weight of 21 g upon death.* Figure 2A and 2B are the results of the simulations with a loss of 21 g upon death. All conditions except the loss of 21 g are the same as in the previous case (a). Although there is a large noise signal caused by the cardiac and breathing activities, the system response shows the loss of about 21 g and a declining history of weight caused by the supposed escaping moisture from the body after the cessation of damped vibrations. This means that as long as MacDougall and his colleague did keep the postmortem bladder and bowel movements upon death within the cot bed, the uncontrolled experimental procedure over the escaping moisture from the body did not practically affect his experimental conclusion that there had been anomalous losses in the weight of his patients upon death.

It was assumed in the above simulations that the initial weight of the experimental subject m_{sp} = 62.0 kg in both cases (a) and (b), and the loss of 21 g occurred instantaneously upon death in (b). The natural vibration frequency f_n of the weighing system changes from 0.59 to 0.51 Hz as m_{sp} changes from 40 to 80 kg (f_n = 0.54 Hz for m_{sp} = 62.0 kg); this change in f_n affects the disturbance effects of the cardiac and breathing activities on the system response before death. The corresponding peak-to-peak swing of system response changes from 78 to 88 gf, which was 80 gf for m_{sp} = 62.0 kg. If the loss of 21 g upon death occurs in a few seconds (instead of instantaneous loss), the damped vibration behavior of the system response after death becomes less remarkable than the result shown above (this was discussed in Ishida, 2009). These uncertainties in m_{sp} and the rate of 21-g loss do not much affect the results of the above simulations.

(c) *Elimination of disturbance noise from system response.* The vibrations in the system response caused by the disturbances are considered to be noise signals in terms of the supposed experimental purpose of measuring the change in weight upon death. The noise appearing in the system response can easily be eliminated from the recorded system response by applying some noise reduction techniques. To eliminate noise caused by the disturbances from the system response R(t), an averaging method can be applied as follows (this was used also in Ishida, 2009):

$$\text{Averaged response: } \langle R(t') \rangle = (1/\,TB) \int R(t)dt, \qquad (2)$$

where the definite integral is calculated over one successive breathing cycle (t, t + TB), and time t′ is defined as the mid-point of the cycle interval. The period of the breathing cycle (TB) is 4.58 s in these simulations.

It should be noted that the period of cardiac cycle (before death) is about 0.94 s in these simulations; hence, one breathing cycle covers almost five cardiac cycles. The system responses based on Equation 2 for the cases calculated

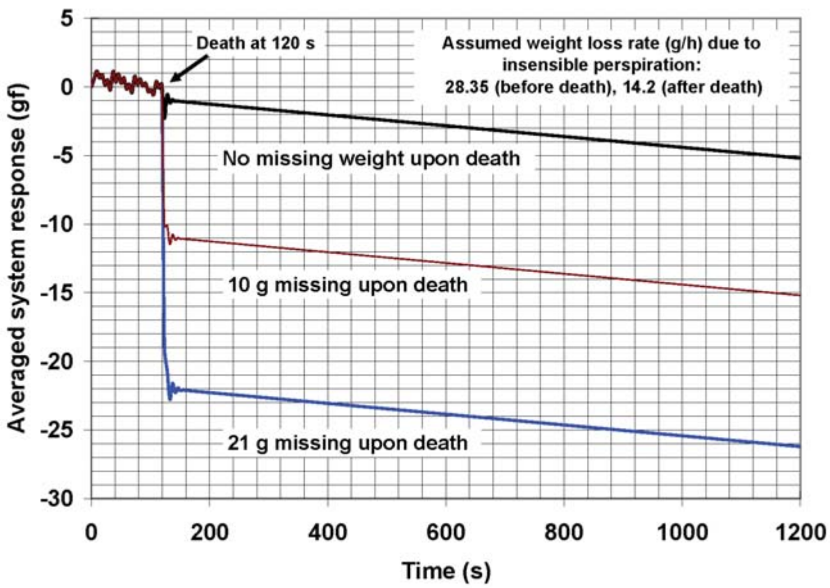

Figure 3. Averaged (over-sampled data) system response (3 cases).

above are shown in Figure 3, which shows another case with an added loss of weight of 10 g. The averaged responses shown in Figure 3 are actually the average over the sampled data from all calculated transient data at a rate of 5 points per second; this sampling is made based upon the assumption that the weight measurement system has a response time of 0.2 s. The relatively remarkable vibrations in the averaged system response before death ($t < 120$ s) comes from the maximized cardiac disturbance together with the assumed small number of data sample points per second.

The averaged system responses clearly show in each simulation the supposed change in weight upon death and the declining history of weight caused by the supposed escaping moisture from the body. Also the result for the case with no missing weight upon death shows as discussed above that it will be difficult to justify any claim of anomalous missing weight of less than about 2 g upon death in human cases. A similar problem exists in cases of animals other than humans.

3.2 Review of Critical Comments

Each critical comment specifically expressed in Section 2 is reviewed here using the simulation results in Section 3.1, with additional analysis when necessary.

(1) ***The experiment was inadequately controlled.***

(a) *The weight loss during the life-to-death transition caused by insensible perspiration was not controlled.* MacDougall reported in his paper (MacDougall, 1907) that the time-average rates of the observed weight loss for Patients 1 and 2 were about 28 and 21 g/h during the few hours prior to their deaths, respectively (see Table 1). He assumed that these were due to the evaporation of respiration moisture and sweat from the dying patients.

According to a standard textbook of dietetics (Goto and Takishita, 1988), heat loss from a healthy adult body due to insensible perspiration is about 21% of the total heat loss per day. If the calorie intake is 2,700 kcal/day, 21% is 567 kcal/day; that is, the average heat loss rate (Q_{ip}) due to insensible perspiration becomes 23.6 kcal/h. The loss rate of water mass M′ corresponding to this heat loss rate can be calculated as follows:

$$M' = Q_{ip} / \Delta_{VAP}H = 40.4 \text{ g/h}, \qquad (3)$$

where $\Delta_{VAP}H$ is the latent heat of water vaporization (2.444 kJ/g = 0.584 kcal/g at 25°C).

This value is about 44% larger than that of Patient 1 (28 g/h). The loss rates MacDougall observed in his experiment are physiologically normal values expected for those dying patients of tuberculosis.

The possible water vapor loss from the dead body covered with bed clothing would have continued at a lower loss rate than that before death, but normally not at a rate of tens of grams moisture loss in a few seconds after the judgment of patient death by MacDougall and his colleague. A possible large mass loss within a few seconds after death can be due to postmortem bladder and bowel movements, which MacDougall mentioned in his paper usually occurred if he failed to contain the movements within the cot bed on the scale platform. MacDougall stated in his paper (MacDougall, 1907) that these movements did not take place in Patient 1.

But these movements, if they occurred, can contribute to water vapor loss from the body as MacDougall stated. In the simulations of Section 3.1, 50% of the loss rate before death was assumed after death; this loss rate of 14.2 g/h, if it continues until about 1 h after death (probably when they terminated the experimental cases), will result in weight loss of 14.2 g, which is well above the sensitivity of MacDougall's scale (5.7 g). However, his scale did not detect any further loss in weight of Patient 1 within the sensitivity of the scale, which suggests that the weight loss rate after the death of Patient 1 was less than 5.7 g/h.

We can say that the uncontrolled weight loss due to escaping water vapor from Patient 1's body definitely occurred during about 1 h after the time of death within the scale sensitivity. However, the simulation results shown in Figures 1–3 clearly show that the missing weight, whether it is 10.6 or 21.3

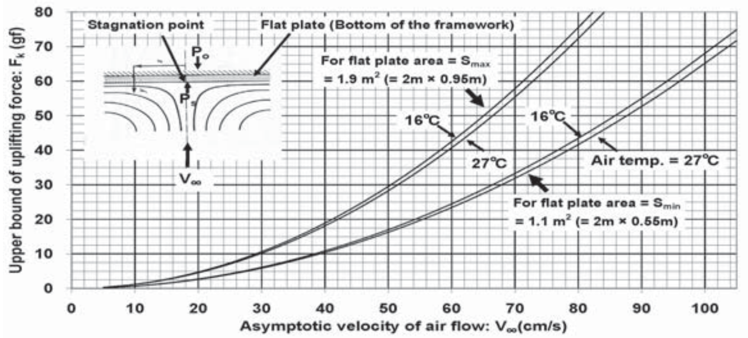

Figure 4. Estimated uplifting force by stagnation-point air flow on a flat plate.

g, cannot be explained based upon the uncontrolled loss of weight due to the escape of water vapor from the dead body.

This means that as long as MacDougall and his colleague did keep the postmortem bladder and bowel movements upon death within the cot bed, the lack of control over escaping moisture from the dead body did not practically affect his experimental conclusion that there were anomalous losses in weight of his patients upon death. How precise his experimental results were for the missing weight is not the essential point, so long as the amount of the missing weight was well above the sensitivity of his scales and the amount of uncontrolled (i.e., escaped) water vapor mass.

Hence, Blackmore's criticism based upon the uncontrolled water vapor loss is refuted.

(b) *Possible effect of convection air currents on the weighing scale was not well controlled (i.e. not avoided).* Fisher's speculation of convection air currents (Fisher, 2004) is difficult because no sudden change or change in a few seconds in the air currents around the dead body can arise from a decrease in the temperature of a just-dead body due to its thermal inertia with a temperature time constant τ of more than 4 h with direct exposure of the body to the ambient air (i.e. naked in open air of 20°C)[6]; the average temperature of the body for this time constant (τ = 4 h) would decrease by roughly 0.01°C ten seconds after death. Because the body was covered with bed clothing, τ would have been much longer than 4 h.

Despite the above reasoning against the convection currents theory, let us quantitatively evaluate a possible mechanical effect of convection air currents on MacDougall's experiment.

Estimate of convection currents to give MacDougall's unexplained loss of weight. There are at least two ways to produce, apart from the "sudden loss," a spurious loss of weight of patients upon death by vertical air currents: (i) push up the bottom of the wooden framework and cot bed on the scale platform and (ii) push down the weight suspended from the other end of the balance beam.[7]

(i) *Pushing up the wooden framework and cot bed.* To estimate the required upward velocity of convection air currents over the flat bottom area of the wooden framework plus cot bed system to produce an uplifting force ranging from 10.6 to 45.8 gf, the area of the flat bottom is necessary; however, this is unknown. Therefore, the area is treated as a parameter *S*. The required force can be estimated by assuming a stagnation-point air flow over a flat plate oriented normal to the upstream flow direction. The flow situation is shown schematically in the inset of Figure 4. (The inset shows a virtual situation; in reality, beneath the flat plate [which was larger than the size of the scale platform], there is a scale platform or floor as imagined from MacDougall's platform scales.) The asymptotic upstream air flow velocity V_∞ is a parameter. The Bernoulli equation for the flow system is given as follows (Bird et al., 1960):

$$(1/2) \times (V_s^2 - V_\infty^2) + \int_{P_\infty}^{P_s} (1/\rho)dp = 0, \tag{4}$$

V_s = flow velocity at stagnation point and is equal to 0;
V_∞ = asymptotic upstream flow velocity normal to the flat plate (m/s);
P_∞ = asymptotic upstream pressure, equal to the atmospheric pressure P_o (1 atm = 1.01325×10^5 N/m^2);
P_s = stagnation-point pressure (N/m^2);
ρ = density of air (1.220 and 1.172 kg/m^3 at 16° and 27°C, respectively, at 1 atm).

The highest pressure on the bottom of the plate appears at the stagnation point. Pressure on the other bottom area is less than the stagnation-point pressure P_s ($P_s = P_o + (1/2)\rho V_\infty^2$ for incompressible fluids). Hence, an upper bound of the uplifting force F_k is evaluated as follows:

$$\begin{aligned} F_k(\text{gf}) &< (P_s - P_o) \times S \times [10^3/9.807] \\ &< (1/2)\rho V_\infty^2 \times S \times [10^3/9.807] \text{ (for incompressible fluids)} \\ &< \{\exp[(M/RT) \times (1/2)V_\infty^2] - 1\} \times P_o \times S \times [10^3/9.807] \\ &\quad \text{(for isothermal ideal gas)} \end{aligned} \tag{5}$$

S = area of the flat bottom of the wooden framework plus cot bed system, assumed to be in the range from 1.1 (2 × 0.55) to 1.9 (2 × 0.95) m^2;
M = molecular weight of air (29×10^{-3} kg/mol);
R = molar gas constant (8.314 J/K/mol);
T = air temperature (K).

Both gas models give almost the same results with the air flow velocity V_∞ sufficiently lower than 13 m/s.

Figure 4 shows the calculated upper bound of the uplifting force F_k as a function of the vertical air flow velocity V_∞ with the area S and air temperature T as parameters. We can probably assume here that the ranges of both parameters in Figure 4 cover the unknown conditions in MacDougall's experiment. The required flow velocity to produce an uplifting force ranging from 10.6 to 45.8 gf becomes 30 to 63 cm/s for S_{max} = 1.9 m^2 and 40 to 83 cm/s for S_{min} = 1.1 m^2. The slightly greater F_k for the lower air temperature in Figure 4 is due to greater air density at lower temperatures.

To provide an idea about how high the required updraft is under natural convection in a closed physician's laboratory, let us imagine a heated vertical plate standing on the floor and exposed to ambient air at room temperature (20°C). Vertical air flow will be generated around the heated plate due to the temperature difference ΔT between the hot plate and ambient air. An experimentally validated analytical solution to the heated vertical-plate problem in a laminar flow regime is given in Eckert and Drake (1972); and the solution gives the maximum vertical velocity of air flow generated by the plate. Figure 5 shows the calculated maximum flow velocity of air as a function of ΔT at several axial heights Z from the bottom of the plate (the length of the vertical plate is assumed to be long enough to cover each axial height without end-

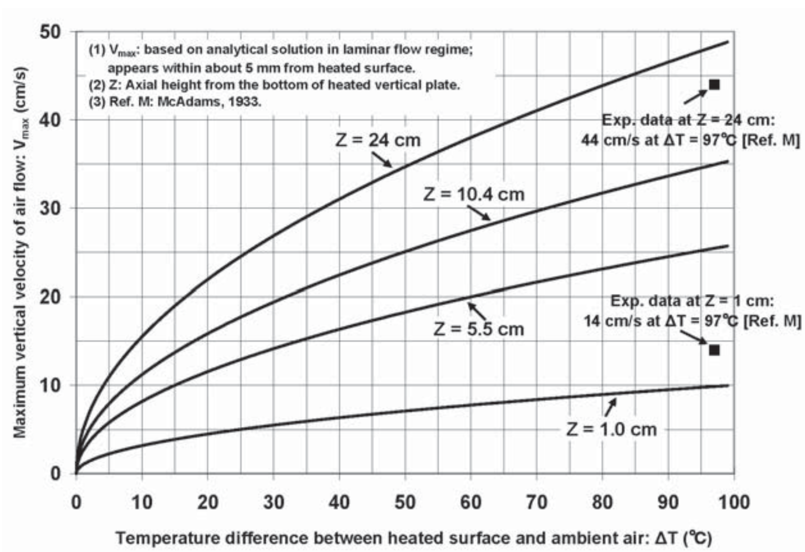

Figure 5. Maximum vertical velocity of air flow generated by heated vertical plate standing on floor and exposed to air at room temperature.

effects). The two curves at Z = 1 and 24 cm give maximum velocities of 10 and 48 cm/s at $\Delta T = 97°C$, respectively, which approximately correspond to the experimentally measured maximum velocities (14 and 44 cm/s, respectively) (McAdams, 1933).

Figure 5 shows that realizing such a localized natural convection updraft of velocity ranging from 30 to 83 cm/s would require a large temperature difference ΔT (which depends upon the size of the heated plate) between a hot object and its ambient air. Therefore, such a flow situation is inconceivable to have been realized upon death in MacDougall's experiment.

(ii) *Pushing down the weight of the scale beam.* To push down the weight on the other side of the scale beam, a downward air flow would be assumed to be directed toward the top of the scale weight (the ratio of the two arms of the beam balance is estimated to be 1:6, based upon the picture of a similar scale on the International Society of Antique Scale Collectors [2009] website). It suffices to say that a more vigorous (localized) downdraft is required than the updraft estimated in (i) because of the small cross-sectional area of the weight compared with the assumed area *S* of the cot bed system. Such a flow situation is also inconceivable to have been realized upon the patients' death. Therefore, Fisher's convection currents theory is refuted.

One important conclusion to be noted here, based on the analysis above, is that in any weight measurement experiment for transitions to and from an altered state of consciousness (discussed in Ishida, 2009), if the experiment is concerned with the change in weight of human subjects on the order of tens of grams and not tens of milligrams, the hydraulic effect of the natural convection of air on the weighing system is minimal.

(2) ***The judgment of the time of death was ambiguous.*** Blackmore's statement quoted in Section 2(2) concerns Patient 2. MacDougall reported two modes of weight loss observed for each case: (a) a loss within a few seconds after the judgment of time of death, and (b) a loss, if any, after the first few seconds up to about 1 h after the judgment of patient death (see Table 1). Blackmore is concerned with the reason for the gradual loss in weight observed in Patients 2 and 3 after the first loss in the first few seconds. These reported losses are about twice or more the initial losses and should be explained. MacDougall (1907) wrote:

> This [second] patient was of a totally different temperament from the first, his death was very gradual, so that we had great doubt from the ordinary evidence to say just what moment he died. (pp. 240–241)[8]

What is certain is that Patient 2 died during the interval between the start and termination of the experiment and MacDougall observed a loss of weight of 45.8 g in total, out of which 14.2 g was observed in a few seconds after the moment they initially thought the patient died. MacDougall did not conclude that all the losses of weight were observed at the moment of death but some were observed in the two modes, and both losses were unaccounted for based upon his scientific knowledge. MacDougall was correct to watch the change in weight of his patients continuously during the experiment. It is not enough for the experiment to weigh the patient just before and after the apparent death. The exact time of death, if any, is not important in his experiment. The question of why the second type (b) of weight loss was observed can never be answered unless the first type of loss (a) is explained. We do not know as of yet the real meaning of human death when we take into account research results on human reincarnation, such as those by the late Professor Ian Stevenson (1918–2007) (Stevenson, 1986).

Therefore, Blackmore's second critical point cannot refute MacDougall's experimental results.

(3) ***MacDougall's fellow doctor Augustus P. Clarke's criticism.*** Clarke's critical points consist of:

(i) the sudden rise in body temperature at death when the blood stops being air-cooled via its circulation through the lungs, and

(ii) the sweating and moisture evaporation caused by this rise in body temperature would account both for the drop in the patients' weight and the dogs' failure to register any decline in weight, as dogs do not have sweat glands; they pant to cool themselves.

Let us consider point (i) for human cases. The local temperature of any part of the body is kept roughly constant (with some daily fluctuations) by biological mechanisms of the human body when it is still alive; that is, the rates of heat generation and heat inflow by the blood flow of a living body in any body part is balanced by the heat removal (heat outflow through blood flow and conduction heat-transfer inside the body) from there. When a person dies, the heat generation (in skeletal muscles and organs) ceases in the body, but heat removal continues through conduction and natural convection heat-transfer inside the dead body and natural convection, radiation, and sweat-evaporation heat-transfer from the body surface. Because of this heat unbalance, even if blood flow stops upon death, there will be no part in the body where its temperature rises upon death (at least until the end of algor mortis). The effect of blood flow stopping in the dead body is a decrease in the heat removal rate compared with the rate in the living state, but this never results in an increase of body temperature. It decreases slowly with a temperature time constant (τ) of more than 4 h. Today's knowledge of forensic
medicine would never support Clarke's claim (i).

As to Clarke's claim (ii) (apart from the dog cases), suppose that, as Clarke suggested, 21 g of sweat suddenly appeared on the body surface through the sweat glands of Patient 1 upon death. What would happen next? The evaporation rate of sweat may increase compared with the rate just before the death because of the supposed transient increase in the moisture mass on the body surface (not because of the rise in body temperature; it falls upon death because of the heat unbalance). Clarke needs to further speculate that the 21 g of moisture evaporates from the body surface in the few seconds. This is a very rapid evaporation, similar to what would occur with a hot heated metal surface. In addition, the patient's body was covered with bed clothing; hence, the supposed 21 g of sweated moisture and its vapor near the body surface would very probably stay within the bed clothing to contribute to the apparent weight of the patient, at least during the initial few seconds after the moment of death. Therefore, Clarke's claims (i) and (ii) are refuted.

(4) ***The sample size of the experimental group is far too small, and the ability to measure changes in weight is less than precise.*** These comments were expressed by Brian Schill (2009) on the website of the International Parapsychology Research Foundation, Inc., as a summary of his critical review of MacDougall's experiment[2].

MacDougall was well aware of the smallness of the sample size and expressed as such in his paper. However, even if MacDougall's sample size were very large, it would not be enough, as MacDougall (1907) stated in his paper:

> I am aware that a large number of experiments would require to be made before the matter can be proven beyond any possibility of error, but . . . (p. 243)

MacDougall's statement above means that any experimental claim cannot be proved to be true unless other independent experiments confirm the claim as true; this is the way of science to avoid systematic errors in the experiment. Four cases are certainly small as an experimental sample size. However, unless his experimental results have been refuted based upon a scientifically quantitative basis, the four cases remain as pioneering cases in the scientific research.

As for the criticism "the ability to measure changes in weight was less than precise," Schill's point is understood here as concerned with the accuracy and sensitivity of MacDougall's scales. The measurement accuracy of any scale depends upon the calibration of the scale together with its sensitivity. Calibration and sensitivity tests of the scale should be conducted before the start of experiments and even between experimental cases. MacDougall did not specifically mention the calibration of his scales, but he described the sensitivity tests[9]. It should be noted that what is important in his experiment is to measure the relative change in weight during the life-to-death transition, and hence, the accuracy of the measurement depends primarily on the scale sensitivity.

Were MacDougall's scales not sensitive enough to measure the change in weight of the patients upon death? This question concerns the sensitivity of the scale, which is 5.7 g (2/10 oz).[9] Is this sensitivity too low to detect the change of 21 g? No, 21 g is well over the sensitivity. This sensitivity roughly corresponds to 1/11,000 for human weight measurements, if the average weight of MacDougall's patients is roughly 62 kg. The weighing system consisting of four load cells used in Section 3.1 has a sensitivity of 5 g for 100 kg; this sensitivity corresponds to 1/20,000, which is about twice as sensitive as MacDougall's equipment. Today we have very sensitive scales; for example, an analytical balance scale with a sensitivity of 10 μg for 40 g (0.25 ppm) was available 10 years ago. However, a scale with a sensitivity of 10 μg for 62 kg is not available, which would correspond to 0.16 ppb. Even if we had such a sensitive scale, the scale would not be useful for weighing humans when the effects of the disturbances and noise discussed in Section 3.1 (as well as the effect of convection currents in Sec. 3.2(1)(b)) are taken into account. Hence, one can say that MacDougall's scales had a good sensitivity for his experimental purpose.

Brian Schill may have based his criticism of MacDougall's scales on the following description by MacDougall in his 1907 paper:

> There remained but one more channel of loss to explore, the expiration of all but the residual air in the lungs. Getting upon the bed myself, my colleague put the beam at actual balance. Inspiration and expiration of air as forcibly as possible by me had no effect upon the beam. My colleague got upon the bed and I placed the beam at balance. Forcible inspiration and expiration of air on his part had no effect. (MacDougall, 1907:239−240)

The vital (lung) capacity of Japanese male adults ranges from 3.5 to 4.5 liters (Yamamoto et al., 1988), and this volume of atmospheric air (at 20°C) has a mass ranging from 4.2 to 5.4 g. Why didn't they get a similar amount of change in the balance? Was the expected effect too small to be detected by their scale's sensitivity at 5.7 g (0.2 oz)? MacDougall discussed nothing about this strange result despite his statement about the sensitivity test of his scale in his paper[9]. This strange result may have occurred because we are always bathing in a bath of atmospheric air in which the Archimedean principle works: i.e., the buoyant force cancels the weight of the air mass inhaled or exhaled. This can be expressed with a couple of equations:

(a) Assume an initial state of body with exhaled lungs with lung capacity of V_a,

(b) Assume a final state with inhaled lungs with lung capacity of V_b.

The increase in body weight dW due to the air mass increase in the lungs becomes:

$$dW = dV \times \rho_{air} \times g = (V_b - V_a) \times \rho_{air} \times g$$

where ρ_{air} and g are the air density and gravitational constant, respectively. Because the body shows approximately the same increase in volume dV for the abdomen in the transition of states from (a) to (b) ($dV = [V_b - V_a]$), this results in an increase in buoyant force on the body $dF_s = dV \times \rho_{air} \times (-g)$, which cancels out the dW; hence, there is no apparent change in weight between the two states (a) and (b). dV is the vital capacity when forcibly inhaled and exhaled.

Even if the buoyant force dF_S does not cancel out the dW, the effect of the air mass change would be well below the detectable limit of MacDougall's scales. In fact, this is confirmed with their demonstration on the bed showing no measurable effect. Their demonstration also showed that the effect of hydraulic reaction to their vigorous breathing on the balance beam was not detected within the scale sensitivity. The analysis in Section 3.2(1)(b) for the required (somewhat energetic) air flow condition may support the results of their demonstration.

(5) ***Other speculations/hypotheses trying to scientifically explain the missing weights.***

(a) Speculation based upon the dynamic effects of heartbeats. The analysis in Section 3.1 with the assumption of "no missing weight upon death," which is shown in Figures 1 and 3, clearly refutes the speculation, which is solely based on the 3-N peak-to-peak amplitude vibrations of CAF.

(b) *Hypothesis of postmortem body swelling.* The buoyant force on the body may have played a tricky role in MacDougall's experiment. This hypothesis speculates that the patients' bodies may have swollen because of muscle relaxation upon death prior to rigor mortis (stiffening of limbs), and the resultant increase in the buoyant force on the swollen body may explain the reported apparent loss of weights. To produce a buoyant force ranging from 10.6 to 45.8 gf at the atmospheric room temperature of 20°C (air density = 1.202 g/L at 20°C, 1 atm), body swelling ranging from 8.8 to 38 liters is necessary to arise in the bodies of patients during the experiment. The experimental subject (62.0 kg) assumed in Section 3.1 has a total volume of about 60.4 liters in a natural state (assuming that the average density of the body equals 4% salt water [1.027 kg/L at 20°C], which is close to the average density of sea water), and the subject has to subtract from his scaled weight a buoyant force of about 72.6 gf to get the correct weight. The supposed body swelling ranging from 8.8 to 38 liters would correspond to the volumetric swelling 14% to 63% in this case. It is unlikely that MacDougall and his colleague failed to notice this remarkable body swelling of their dead patients when they examined the patients' postmortem bladder and bowel movements; postmortem body swelling was not an item included in the signs of death for the forensic postmortem examinations (Saferstein, 1998). Therefore, the hypothesis of postmortem body swelling is rejected.

4. Concluding Remarks

4.1 Measurement Error in MacDougall's Experiment?

Before concluding this paper, we need to determine whether or not there are any fatal errors in MacDougall's experiment. We know that uncertainties accompany any experimentally measured data: These uncertainties include random and systematic errors.

Random errors are likely to appear in MacDougall's data within the sensitivity of his scales (5.7 g) with an equal probability of positive or negative sign when there are a large number of the measured cases. Even if we assume that random errors always appear with the negative sign in his measured data (whose probability of occurrence becomes $(1/2)^4 = (1/16)$ under the assumption that random errors exhibit a normal distribution), the minimum of missing weights for the four cases ranges from 4.9 to 40.1 g, though the accuracy of scales should be taken into account. These minima still exist on the negative (i.e. missing) side. We can say that random errors were almost certainly not the reason for MacDougall's missing weights.

Were there any systematic errors expected in his data? One systematic characteristic in his data, apart from measurement errors, is his reported sudden or in-a-few-seconds drop of the balance beam at the occurrence of apparent death for each one of the four cases. Any systematic error in the data would result from the scales, experimental conditions, and experimenters. Regarding the experimental conditions, we have discussed to some extent the possibility of errors (i.e., the claimed criticisms against the experiment) in Section 3.2. If there had been any systematic error in the experiment, it would have also appeared in the 15 dog cases; however, MacDougall's statement "the results were uniformly negative; no loss of weight at death" (MacDougall, 1907:241−242) seems to imply that no systematic errors existed. On the other hand, the systematic errors had yielded uniformly null results for the dog cases (within the sensitivity of scales for dog cases). According to our current understanding of the laws of physics, the unaccounted for change in weight during the life-to-death transition should be zero; that is, any measured data should scatter roughly within the sensitivity of scales with a simple average of zero. However, MacDougall's four data points of the change in weight distribute only on the negative side, beyond the range of the scale sensitivity. Nevertheless, primarily because of the presence of systematic errors, it is essential to perform independent confirmation experiments to obtain important experimental results in order to avoid any fatal biases possibly caused by errors in the experiment. As quoted in Section 3.2(4), MacDougall was well aware of the necessity of independent confirmation experiments.

Therefore, the conclusion of this study is that Dr. Duncan MacDougall's experiment was adequately controlled for the measurement of the change in weight of more than 10 g, not less than a few grams, in the life-to-death transition of his patients, although he did not perform his experiment with those six brave volunteering patients in a completely isolated system. All the cases under which he performed the experiment remain to be pioneering cases ever published in a scientific journal.

Nevertheless, someone is likely to propose a scientific explanation of MacDougall's missing weights on the basis of some known physicochemical mechanisms. Any mechanism used to explain weight loss should satisfy the following requirements. Change in weight W(t) of an experimental subject can be expressed as follows:

$$dW/dt = R(t, W(t)),$$

where R(t, W(t)) is the rate of change in weight with time caused by certain physicochemical mechanism(s) that in turn may depend on W(t). W(t) changes only slightly (probably by less than 0.1% of its initial value W_0) as shown in MacDougall's data; hence, R(t, W(t)) can be approximated with $R(t, W_0)$. If $R(t, W_0)$ is given, the change in W(t) during a time interval from 0 (time of death) to t (elapsed time after death) can be calculated as follows:

$$\Delta W(t) = \int_0^t R(t, W_0)dt.$$

To explain the sudden decrease in weight upon death, as observed during MacDougall's experiment (see Figure 3), $R(t, W_0)$ should be proportional to δ(t) (Dirac's delta function), if not strictly so. The requirements are (1) $|R(t, W_0)|$ must have a relatively large value only for a few seconds after the time of apparent death and (2) $R(t, W_0)$ must reduce to almost zero for W(t) to remain almost constant at least for a short time after the few seconds. Therefore, any scientific theory that is proposed to explain the loss of weight upon death, as observed in MacDougall's experiment, must be based on a physicochemical mechanism that satisfies requirements (1) and (2). However, for example, the rate of loss of weight due to insensible perspiration does not satisfy these requirements. In the field of forensic medicine, it is known that cellular decomposition starts immediately after death, and resultant gases are released from the dead body over time. This mechanism also does not satisfy the above two requirements. Therefore, it will be very difficult to scientifically explain the loss of weight upon death, as observed in MacDougall's experiment. One may say that the change of 0.1% is a small fraction of W_0. Nevertheless, it is not negligible when one understands the following scientific fact.

4.2 Theoretical Implications of MacDougall's Data

If MacDougall's missing weights are determined by performing other similar types of experiments, as suggested in Ishida (2009), what would missing weights then imply? Table 2 shows a comparison among percent-mass-deficits ($\%\Delta M/M_0$) of some physical, chemical, and life-to-death transition events. In this table, the first four rows show the $\%\Delta M/M_0$ required for the release of energy (ΔE) from the well-known reactions in physics and chemistry; these values are calculated on the basis of the law of conservation of energy and Einstein's equation $\Delta E = \Delta M \times c^2$. We know that these mass deficits are associated with the reactions in the first four rows; however, only the mass deficits associated with nuclear reactions (No. 3 and 4) have been experimentally confirmed. The $\%\Delta M/M_0$ in freezing water is too small to be detected using our current scientific instruments as well

TABLE 2

Percent-Mass-Deficits Associated with Some Physical, Chemical, and Life-to-Death Transition Events

No.	Transition Event	Mass Deficit dM (gram) per Associated Mass	% Deficit (dM/M_o×100)[a]	Where Did the Lost Mass/Energy Go?	Note[b]
1	1 kg water freezing in Rumford's Bottle A (M_0 = 266 g × 3.76)	3.76×10^{-9}	3.76×10^{-10}	Used to heat up the cold lab air	Latent heat of water freezing = 6.01 kJ/mol
2	Chemical combustion of 1 kg (H_2 + [1/2]O_2)	1.77×10^{-7}	1.77×10^{-8}	Can be used for automobile fuel	286 kJ/mol H_2 combustion
3	Nuclear fission of 1 kg U-235	0.891	0.089	Being used to generate electricity in nuclear fission power plants	195 MeV/U-235 fission
4	Nuclear fusion of 1 kg (D+T)	3.754	0.375	Could be used to generate electricity in nuclear fusion power plants in the far future	Fusion reaction: D+T = He-4 (3.5 MeV) + n (14.1 MeV)
5	Four cases of life-to-death transition in MacDougall's 1907 experiment	10.6 to 45.8	0.017 to 0.074)	Probably the mass is related to the weight of the individual's experiences at the end of physical life; the experiences will be transferred to and stored in the mind/inner self after physical death [see Section 4(3)(a)]	Assumed average body weight of the dying TB patients at the end of life M_0 = 62 kg (137 lb)

[a] Sensitivity of the most advanced analytical balance may be on the order of $1/10^7$, i.e. $1\%/10^5 = 10^{-5}\%$.
[b] 1 MeV = 1.60218×10^{-13} J.

as Count Rumford's balance (with a sensitivity of 0.27 mg for his water flask). For the same reason, $\%\Delta M/M_0$ in H_2 combustion has not yet been directly confirmed. However, the result of comparing these four rows roughly shows the well-known fact that molecular and chemical bond energies are extremely small compared with nuclear binding energy.

The value of $\%\Delta M/M_0$ in the fifth row is calculated formally using MacDougall's missing weight data (ΔM) and the assumed average weight of the dying tuberculosis patients (M_0 = 62 kg); the calculated value of $\%\Delta M/M_0$ ranges from 0.017% to 0.074%. This value may be formally interpreted that if there is a *psychophysical interaction* between the physical body and the assumed nonphysical mind of humans, the associated energy of the interaction is considered to be comparable to that of nuclear binding energy, and the missing mass implies a violation of *the law of conservation of energy* that is an empirical principle based on the assumption that our physical dimension is a closed system. The assumption of our physical dimension being a closed system may be wrong in the life-to-death transition: otherwise, there must be a huge explosion like a nuclear one at each human death.

4.3 Suggested Experimental Approach

Psychologist Harvey Irwin (1985), in his book on psychological study of out-of-body experiences (OBEs), reviewed the past weight measurement experiments performed to determine the weight of a supposed exteriorized entity (i.e., astral body); the results of his review can be summarized to the effect that no direct measurements of the "astral self's mass" had been performed because its mass was inferred from a change in weight observed in OBE experients. Additionally, these investigations had studied only individuals (or animals) at the point of death (Irwin, 1985:65), such as in the case of MacDougall's experiment (there is no direct reference to MacDougall's experiment in Irwin). After Blackmore referred to MacDougall's experiment, she wrote in another book that "Better designed modern experiments have led to the conclusion that nothing can be reliably detected leaving the body during OBEs" (Blackmore, 1993:181).

Both authors apparently assume that if the law of conservation of energy is applicable to the subjective phenomenon of OBEs, the weight or mass or energy of the supposed astral body should somehow be detected. However, if MacDougall's missing weight data are authentic, we need to assume that the missing mass/energy is transferred (or returned) to somewhere either (1) in an unknown nonphysical dimension in which the assumed nonphysical mind belongs or (2) in an unobservable physical dimension such as the fifth dimension currently postulated by some theoretical physicists. Probably, it must also be supposed that the astral body enters into the above-mentioned somewhere during OBEs; therefore, any effort to measure the physical weight of the astral body may be in vain.

Then, what we should do next is to observe the change in the weight in the OBE experient. In Ishida (2009), the present author showed a numerical simulation of a supposed weight measurement experiment on an OBE subject using a mathematical oscillation model for the modern weighing system under an assumption that the subject loses 21 g of weight during OBE; the author concluded that if the change in weight of the experimental subject is on the order of tens of grams, noise effects of the cardiac and breathing activities are not a fatal disturbance. There is no basis for the assumption of this weight loss (21 g) or any anomalous loss during OBEs; the assumption should be tested by performing better-designed modern experiments, despite Blackmore's apparently negative statement and despite the present situation that the study of OBE phenomenon is dominated by researchers who are inclined to explain the phenomenon materialistically based on neuroscience.

Frankly, the study of Ishida (2009) was initially motivated by a certain *psychical knowledge* dictated by the alleged nonphysical entity *Seth* through the trance channeling of the writer/poet Jane Roberts (1929–1984). The present author would like to quote relevant parts of this subject from some sessions (with permission from the copyright holders). From this author's point of view, some of *Seth*'s statements given below are scientifically verifiable for their scientific validity, and actually some of the reported phenomena described in the psychical research (e.g., Carrington, 1919, 1939) appear to agree with the following statements of *Seth*'s, which will be interesting to researchers in this field.

(a) ***Quotations from* Seth*'s sessions.*** The following quotation was dictated after *Seth* spoke about "electromagnetic systems" (*Seth*'s term) that are related to, for example, telepathic communications and clairvoyance (or to be more precise, precognition [*Seth*'s phrase]), in a few preceding sessions. The underlines in the quotations below are *Seth*'s; italics have been added by the present author. Interested readers should refer to the original references to clarify any ambiguities in the dictations because only a part of the original text in the quoted sessions is provided by this author.

> Good evening.
>
> *("Good evening,* Seth.*")*
>
> Now. These electromagnetic changes form their own <u>kind</u> of pattern, which has mass but no weight, or weight so slight as to be indistinguishable.
>
> The mass, generally speaking, is a denseness formed by the varying intensities. There are mathematical precisions and formulas here. There is a ratio between the mass, which is usually considerable, and the weight, which is barely noticeable. These electromagnetic frameworks could be considered as skeleton forms within physical matter.

> The electromagnetic reality within the human organism has considerable mass, but *the entire physical weight amounts to 3 to 6 ounces at the very most*. Again, the mass is composed of electrical intensities. I have told you that all experience is basically psychological, and that it is held in coded form within the cells. One electrical pulsation can represent an emotional experience. The importance of the experience to the individual will be responsible for the intensity with which it is recorded. (Roberts, 1998:323, *ES4*/Session 197 on October 11, 1965)

(This author's note: The concept of "mass" in *Seth*'s term above differs from our concept of mass, which corresponds to the physical "weight" in *Seth*'s term above. Further, the "electromagnetic" reality in *Seth*'s term seems to be a more general concept in which our electromagnetic field is only a small portion manifesting in our physical dimension. These differences are mentioned in other sessions. *ES4* stands for *The Early Sessions Book 4* in the representation of Roberts' references.)

(This author's note: The quotations below are taken from some of the sessions in which *Seth* spoke about an individual's dream and out-of-body states.)

> You focus your awareness in altered form into another universe, that is in every way as valid and permanent as your own. It is also as changing as the physical universe. A small amount of energy only is focused upon the physical field during sleep, enough simply to maintain the physical body within its physical environment (Roberts, 1998:2, *ES4*/Session 149 on April 26, 1965).
>
> Now your consciousness will not be in it [the physical body], but it is hardly lifeless. Its maintenance is being controlled by the consciousness of the individual cells and organs of which we have spoken (Roberts, 1999b:210, *ES6*/Session 265 on June 6, 1966).
>
> Almost all of your dream experiences do involve projection of one kind or another. These experiences vary in intensity, type, and even duration as any other experiences vary. It takes a good deal of training and competence to operate with any real effectiveness within these situations.
>
> All in all the intellect plays some part, but the intuitional qualities are the most important. There are chemical changes that occur with the physical body when projections occur. There are also electromagnetic variations. These vary according to the form in which the projection occurs.
>
> The projected form does make some impression upon your physical system. In other words, it is possible for it to be detected. It is a kind of pseudo-image, materialistically speaking, but it has definite electromagnetic reality, and chemical properties.
>
> Now. Animals have indeed sensed such apparitions. There is hardly any magic involved. They react to the chemical properties of the apparition, and build up the image from it—from them, the properties.
>
> These chemical properties however are more diffuse in an apparition than in a physical form. The chemical composition of a storm perhaps will give you an idea of what I mean. They are indeed small disturbances, you see—they form small disturbances within your physical system.

> As a rule they are not <u>solid</u> in the same way that clouds are not solid, and yet they have shape, and to a certain extent boundaries, and of course movement. They definitely have a reality, you see, though you cannot usually perceive it with the physical senses.
>
> Perhaps this diffused quality is the most important difference between such an apparition and a physical form. There is an atomic structure. In some ways however the structure is less complete than a physical form. *There is always a minute difference in the physical body's normal weight when the individual is projecting*. The excess chemicals built up during the waking condition are used to help form the projecting images. There is a slight loss of electromagnetic potency and chemical potency when the individual is projecting (Roberts, 1999b:252–253, *ES6*/Session 269 on June 20, 1966).

Additionally, *Seth* talked about the meaning of "physical death" in his first book *Seth Speaks* (Roberts, 1994/1972), and he said in effect that at death our consciousness may withdraw from our body slowly or quickly, depending on many variables, probably including our psychological dispositions (see Roberts, 1994:119, *Speaks*/Session 535 on June 17, 1970). This may give an insight on how to answer Blackmore's critical point regarding "death timing" against MacDougall's experiment.

(This author's note: "Consciousness" in *Seth*'s term may cover the one[s] in psychology or philosophy, but it is more general as imagined from one of the short quotations above; *Seth* defined a concept of "Unit of Consciousness" in his book [Roberts, 1996a/*Unknown* Vol. 1]. The three forms of exteriorized entity with different capabilities during OBEs are explained in [Roberts, 1999b:179–180, *ES6*/Session 261 on May 23, 1966]. This may give an insight to answer Irwin's second issue [concerning theories of OBE] pertaining to the source of mentation in the OBE: "What are the informational origins of the imagery with the exteriorized perspective?" [Irwin, 1985:219].)

Probably the psychical knowledge quoted above may exemplify the idea of the modular model of mind/matter manifestations, M^5, of Robert Jahn and Brenda Dunne (2001). (However, this does not mean that the M^5 supports the psychical knowledge or the knowledge supports the whole idea of the M^5.)

(b) ***Suggested experiments.*** The primary objective of the weighing experiments at this stage should be to demonstrate an authentic violation of the law of conservation of energy in a transition event that is associated with human consciousness or equivalently to demonstrate that our physical dimension cannot be assumed to be a closed system in the events that are associated with human consciousness. According to the psychical knowledge quoted above, probably the expected change in weight is associated with the "unconscious" (discovered in the field of dynamic psychiatry [Ellenberger, 1970]) as well as the "conscious ego"; the latter ego is supposed to be specific to humans only. Table 3 lists the probable weighing experiments to be performed using subjects, where

TABLE 3
Probable Experiments in Transitions to and from ASC and of Life-to-Death

Category of Events	Experimental Subject	Objective	Previously Conducted Experiments
(a) Transition to and from ASC-1 (OBE, sleeping, hypnotic trance, etc.)	(1) Mediums, (2) people especially talented with PK, ESP, etc.	To measure a decrease in and return of the weight of the subject associated with PPI	Numerous experiments to detect orweigh astral body during OBE with negative results (Blackmore, 1993; Irwin, 1985). A few experiments to detect the change in weight of subjects in some type of ASC with records of some sharply peaked weight-increase signals of paranormal characteristics (Hasted et al., 1983)
(b) Transition to and from ASC-2 (trance-channeling)	(1) Mediums capable of trance-channeling	To measure a change in the weight of trance-channeler	One piece of circumstantial evidence exists (Roberts, 1999a, 2002), which suggested an increase in the weight of the subject.
(c) Life-to-death transition	(1) Humans, (2) animals	This is a to-weigh-the-"soul"–type experiment.	(1) MacDougall's (1907) experiment on humans and dogs, (2) Twining's experiment on mice (Carrington, 1939), (3) Hollander's 2001 experiment on sheep

ASC, altered state of consciousness; ESP, extrasensory perception; OBE, out-of-body experience; PK, psychokinesis; PPI, psychophysical interaction.

transition to and from ASC (altered state of consciousness) and a life-to-death transition can be observed. On the basis of the psychical knowledge, the present author supposes that the possible change in weight to be observed in the events of categories (a) and (b) are "*3 to 6 ounces* [i.e. 85 to 170 g] *at the very most*" in human adults. In particular, in 2009 this author recommended that weighing experiments of category (b) should be performed using a trance channeler in order to achieve the above-mentioned primary purpose of the experiment based on a circumstantial evidence (Roberts, 1999a/*ES5*:89, 2002/*ES9*:161−162; in the former *Seth* proposed an idea to measure Jane's weight (as well as blood pressure) before, during, and after sessions to find out how much he [*Seth*] weighed, which was not realized; in the latter an invited witness perceived an increase in Jane's weight during a session compared with her weight before and after the session based on the appearance [during the session] and disappearance [after the session] of the creaking sound of the floor caused by Jane on her rocking chair), which suggests that the increase in the normal weight of Jane Roberts in the particular case was significantly greater than 6 oz. *Seth* explained the structure of Jane's personality during his sessions on trance channeling as follows:

> In regular sessions, as now, he [meaning Ruburt, i.e. Jane Roberts] and I again both make adjustments, and so in sessions I am what I call a bridge personality, composed of a composite self—Ruburt and I meeting and merging to form a personality that is not truly either of us, but a new one that exists between dimensions. Beyond that is my real identity. (Roberts, 1996b:338, *Unknown* Vol. 2/Session 711 on October 9, 1974)[10]

Additionally, regarding category (b), it will be worth mentioning that patients with the so-called multiple personality disorder are experiencing other kind of ASC when they switch between different personalities. *Seth* talked about this phenomenon in Sessions 255 and 256 in relation to "reincarnation" and our concept of "time," taking the well-known case in the book *The Three Faces of Eve* (Thigpen and Cleckley, 1957). (Session 255 was held on the occasion of Jane Roberts just finishing reading the book.) *Seth* explained that even physical changes would appear when a personality switches to another personality within her (four personalities in all in this case), mentioning two of them being allergic to nylon, while the other two not being allergic (Roberts, 1999b:133–135, *ES6*/Session 256 on May 4, 1966). Similar physiological or physical changes were described by the clinical social worker Lynn Wilson in the book with Joan Frances Casey *The Flock* (Casey with Wilson, 1991). The present author speculates from the observations reported by Wilson (p. 28) that the normal weight of the personality would have changed discontinuously when switching between personalities occurred, and, of course, this could never happen from the view point of our current scientific knowledge. It will be very much problematic to get these patients involved as experimental subjects; however, it is also important for these patients to understand what is happening in themselves. *Seth* is explaining his very interesting idea (in terms of "reincarnation" and his concept of "simultaneous time [i.e. all experiences are happening simultaneously in the spacious present]") eloquently in the case of *Eve* in Session 256.

Repeating category (c) experiments is not only considered to be as objectionable today (when people often die equipped with a resuscitator) as it was 100 years ago (see the case of Patient 4 in Table 1), if not legally forbidden, but also performing such experiments will never promote scientific research on this subject. Even if a modern weighing "soul" experiment on humans (as discussed in Section 3.1(3), performing such experiments using animals will be meaningless as well as difficult due to disturbance effects) gives a positive result, as in the case of MacDougall's experiment, it is necessary to perform category (a) and (b) experiments; these experiments are repeatable and are much more meaningful than those performed to weigh the "soul." We have scientific research results on human reincarnation, for example results obtained by Stevenson (1986). If experimental results of categories (a) and (b) are positive, "the eternal validity of the soul" (*Seth*'s phrase; Roberts, 2002/*ES9*:444) would be concluded from them together with Professor Stevenson's lifework on human reincarnation. Besides, it should be noted that researchers in this field (including this author) are always afraid that their research results of the category (c) experiment will be misinterpreted or misused by non-specialists in this field including mass media for their personal interests, profits, etc.

4.4 Concluding Paper

In 1799, the Count of Rumford, Sir Benjamin Thompson, published an experimental thesis entitled "An Inquiry Concerning the Weight Ascribed to Heat" in a British scientific journal. The objective of Rumford's experiment was to show that heat is not a substance that exhibits weight, but it is an internal vibratory motion of the constituent parts of heated bodies. Einstein (1905) theoretically showed that mass and energy are both different manifestations of the same thing, which was experimentally verified. Today we know heat is a form of energy (ΔE) that contributes to the weighable mass (ΔM) of a heated body based on $\Delta M = \Delta E/c^2$. Therefore, in a sense, Rumford was wrong.

About 100 years after Rumford's paper on the weight of heat, MacDougall's paper in 1907 reported on the weight of a "soul substance." Reading Rumford's paper, Len Fisher (2004) acquired the idea of convection currents to refute in vain the idea of a weighable soul substance.

The present author speculates that for an explanation of the missing weights in MacDougall's experiment, we have to wait for another Einstein to propose a scientific theory, which would state that "consciousness, energy, and mass, all of these are different manifestations of the same thing." *Seth* is telling us that "Scientists say now that energy and matter are one. They must take the next full step to realize that consciousness and energy and matter are one" (Roberts, 1997a:114, *Dreams* Vol. 1/Session 881 on September 25, 1979).[11]

MacDougall's experiment is concerned with human consciousness, which is one of most enigmatic subjects in current scientific fields. One may say that this author is falling into a pitfall of dualism. This author does not think so. His speculation resumes: probably MacDougall did his experiment using the physical patients that his "Inner self" (*Seth*'s term)[12] created before and after their deaths in his *subjective world* or in his *ostensibly objective world*, basically in the same way that a legitimate physical medium materialized a pseudo-image personality in séances.[13] *Seth* dictated: (at death) "It [the consciousness] merely ceases to construct the physical image. There is no great mystery here. What seems a mystery is merely the result of ignorance" (Roberts, 1997b:80, *ES2*/Session 51 on May 6, 1964).

Notes

[1] The present author concludes, based on thermo-hydraulic analysis, that the probable cause of the peculiar results in Rumford's experiments would have been (b) assisted by (a) during the process of water freezing, in which "uncontrollable" upward air currents around the water flask (at 0°C) collected more moisture on its surface than the unfrozen wine flask, whose temperature followed the ambient air temperature of below zero. An essential difference in the experimental procedures between the two phases of his experiments (Thompson, 1799) was that it resulted in less clean glass surfaces of the flasks in the earlier phase experiments than in the later phase ones before removing them into his cold laboratory of below zero temperature. This less-cleanness would have enhanced the difference in moisture attachment between the two flasks in the peculiar cases.

[2] The present author does not have direct information on this critical comment published in the letters column of *American Medicine*; hence, the review is made by partially quoting the article: "21 Grams: The Weight of Truth or Deception?" by Brian Schill (2009), founder of the International Parapsychology Research Foundation (IPRF) Inc.

[3] Because the patient is supposed to be lying supine on the bed, the F_x component, which is the "frontward–backward" cardiac force obtained from the experimental subjects standing upright and shows a peak-to-peak swing of less than one-third of F_y, is suitable for use in this simulation. However, because the most predominant CAF is the vertical F_y ("upward–downward") component in Conforto et al. (2002), F_y has been used to visualize the disturbance effect caused by the largest amplitude vibrations.

[4] This is apart from the buoyant force on the body before and after death; it is estimated to be about 73 gf in Section 3.2(5)(b).

[5] This relatively large value originates from the use of the F_y component of the CAF with the maximized 3-N swing in the simulation; this value reduces to +0.08 gf if the F_x component with a maximized swing of 0.4 N (Conforto et al., 2002) is used[3].

[6] Temperature time constant is define as $\tau \equiv (MC_p)/(h_{eff}A)$, where MC_p is the heat capacity of the body, A is the heat-transfer area of the body, and h_{eff} is the effective heat-transfer coefficient, which is about 10 W/m^2/K for natural convection heat transfer (through convection, radiation, and sweat evaporation) under the above-mentioned condition. The difference between the average body ($T_b(t)$) and ambient air (T_{air}) temperatures $\theta(t)$ (= $T_b(t) - T_{air}$) changes as $\theta(t)/\theta_0 = \exp(-t/\tau)$, where θ_0 is the initial value of $\theta(t)$. The time constant $\tau \approx 4$ h was calculated for this author's body using the following data: M = 62 kg, A = 1.64 m^2 (for stature H = 1.58 m), $C_p \approx 4.18 \times 10^3$ J/kg/K, h_{eff} = 10 W/m^2/K, $T_b(t = 0)$ = 36.5°C, and T_{air} = 20°C. Various parts of the body were modeled as horizontal cylinders for the evaluation of h_{eff}.

[7] A similar type scale to the ones MacDougall used in his experiment can be found on the International Society of Antique Scale Collectors (2009) website.

[8] All the quotations from MacDougall's paper (1907) were made based on the one published in the *Journal of the American Society for Psychical Research*.

[9] In 1907, MacDougall wrote in the description of his second patient: "My scales were sensitive to two-tenths of an ounce. If placed at balance one-tenth of an ounce would lift the beam up close to the upper limiting bar, another one-tenth ounce would bring it up and keep it in direct contact, then if the two-tenths were removed the beam

would drop to the lower bar and then slowly oscillate till balance was reached again" (p. 240).

10 From the book *The Unknown Reality*, *A Seth Book. Volume 2* ©1996, Jane Roberts. Reprinted by permission of Amber Allen Publishing, Inc., P.O. Box 6657, San Rafael, CA 94903. All rights reserved.

11 From the book *Dreams, "Evolution" and Value Fulfillment, A Seth Book*. *Volume One* ©1997, Jane Roberts. Reprinted by permission of Amber Allen Publishing, Inc., P.O. Box 6657, San Rafael, CA 94903. All rights reserved.

12 The inner self (the creator of the conscious ego to represent itself in the physical dimension) may corresponds to the "unconscious" (which is the term created by the conscious egos) discovered in the field of dynamic psychiatry (Ellenberger, 1970) or the undiscovered "Self" in Carl G. Jung's terms (Jung, 1966, 1975), although *Seth* is very critical of the limited/distorted knowledge of Freud and Jung about the unconscious (see, for example, Roberts, 1997b:321−327, *ES2*/Session 83 on August 3, 1964).

13 Philosopher Stephen Braude (1986) positively speculates if there is psi at all, then there should be everyday psi to result in ordinary sorts of events—not flagrant object levitations, materializations, or other events that automatically call attention to themselves. MacDougall's creation of his patients did not call attention as it is everyday psi; *Seth* refers to such creations as "energy transformation," saying that you are learning energy transformation on your particular camouflage universe (Roberts, 1997b/*ES2*:15).

Acknowledgments

The present author would like to thank Mr. Rick Stack, President of New Awareness Network Inc., and Amber-Allen Publishing for their kindhearted permissions for the quotations of the *Seth* material published in the books referred to in this paper. This author also wishes to thank Professor Carlos Alvarado, University of Virginia Health System, and the responsible Editors of the *Journal of Scientific Exploration* for their kindhearted help in accessing the 102-year-old MacDougall paper published in the *Journal of the American Society for Psychical Research*. Further, this author also immensely appreciates the knowledge imparted by *Seth* in typically contemporary terms through Jane Roberts and her late husband Robert F. Butts (1919−2008); without this knowledge, this author would never have attempted to publish this paper as well as the previous one (Ishida, 2009).

References

Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (1960). *Transport Phenomena* (pp. 212−213). Wiley.

Blackmore, S. J. (1992). *Beyond the Body: An Investigation of Out-of-the-Body Experiences* with a New Postscript by the Author (chap. 19, pp. 203−205). Chicago: Academy. (Originally published 1982. London: Heinemann)

Blackmore, S. J. (1993). *Dying to Live–Near-Death Experience*s (p. 181). Buffalo, NY: Prometheus.

Braude, S. E. (1986). *The Limits of Influence: Psychokinesis and the Philosophy of Science* (p. 222). New York/London: Routledge & Kegan Paul.

Carrington, H. (1919). *Modern Psychical Phenomena: Recent Researches and Speculations.* New York: Dodd, Mead and Company.

Carrington, H. (1939). *Laboratory Investigations into Psychic Phenomena.* Philadelphia: David McKay.

Casey, J. F., & Wilson, L. (1991). *The Flock—The Autobiography of a Multiple Personality.* The Random House Publishing Group. (Ballantine Books Edition 1992)

Conforto, S., Schmid, M., Camomillia, V., D'Alessio, T., & Cappozzo, A. (2002). Hemodynamics as a possible internal mechanical disturbance to balance. Available at: http://www.laboratorium.dist.unige.it/~piero/Workshop2002/dalessio-1.PDF. Accessed 5 May 2009.

Eckert, E. R. G., & Drake, R. M., Jr. (1972). *Analysis of Heat and Mass Transfer* (p. 526). McGraw-Hill.

Einstein, A. (1905). Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? *Annalen der Physik und Chemie, 18,* 639−641.

Ellenberger, H. F. (1970). *The Discovery of the Unconscious: The History and Evolution of Dynamic Psychiatry.* New York: Basic Books.

Fisher, L. (2004). *Weighing the Soul: Scientific Discovery from the Brilliant to the Bizarre* (chap. 1, pp. 1−22). New York: Arcade.

Goto, M., & Takishit, S. (1988). *New Clinical Dietetics* (p. 210) [Japanese]. Tokyo: Nan-e-do.

Hasted, J. B., Robertson, D., & Spinelli, E. (1983). Recording of sudden paranormal change of body weight [Research briefs]. In Roll, W., Beloff, J., & White, R. (Eds.), *Research in Parapsychology,* 1982 (pp. 105−106). Metuchen, NJ: Scarecrow Press.

Hollander, L. E., Jr. (2001). Unexplained weight gain transients at the moment of death. *Journal of Scientific Exploration, 15,* 495−501. (Available at: http://www.scientificexploration.org)

International Society of Antique Scale Collectors (2009). *Gallery*. Available at: http://www.isasc.org/. Accessed 5 May 2009.

Irwin, H. J. (1985). *Flight of Mind: A Psychological Study of the Out-of-Body Experience*. Metuchen, NJ: Scarecrow Press.

Ishida, M. (2009). A new experimental approach to weight change experiments at the moment of death with a review of Lewis E. Hollander's experiments on sheep. *Journal of Scientific Exploration, 23,* 5−28.

Jahn, R. G., & Dunne, B. J. (2001). A modular model of mind/matter manifestations (M^5). *Journal of Scientific Exploration, 15,* 299−329.

Jung, C. G. (1966). II: The relations between the ego and the unconscious. In Jung, C. G., *Two Essays on Analytical Psychology* (pp. 121–241). Princeton University Press.

Jung, C. G. (1975). IV: The undiscovered self. In Jung, C. G., *Civilization in Transition* (pp. 245–305). Princeton University Press.

MacDougall, D. (1907). Hypothesis concerning soul substance together with experimental evidence of the existence of soul substance. *American Medicine, 2,* 240−243. (Quotes in this paper from the version in *Journal of the American Society for Psychical Research, 1*(5), 237−244, 1907.)

McAdams, W. H. (1933). *Heat Transmission* (3rd ed.). McGraw-Hill. (Int'l Student Ed., 1954, p. 167.)

Roberts, J. (1994). *Seth Speaks* (p. 119, Session 535 on June 17, 1970). San Rafael, CA: Amber-Allen; Novato, CA: New World Library. (Originally published 1972, Prentice-Hall)

Roberts, J. (1996a). *The "Unknown" Reality: A Seth Book* (Vol. 1, pp. 39−42, 48−55, 59−60, Sessions 682, 683, 684, in February 1974). San Rafael, CA: Amber-Allen. (Originally published 1977, Prentice-Hall)

Roberts, J. (1996b). *The "Unknown" Reality: A Seth Book* (Vol. 2, p. 338, Session 711 on October 9, 1974). San Rafael, CA: Amber-Allen Pub. (Originally published in 1979, Prentice-Hall)

Roberts, J. (1997a). *Dreams, "Evolution," and Value Fulfillment* (Vol. 1, p. 114, Session 881 on September 25, 1979). San Rafael, CA: Amber-Allen Pub. (Originally published 1986, Prentice-Hall.)

Roberts, J. (1997b). *The Early Sessions: Book 2 of The Seth Material.* Manhasset, NY: New Awareness Network.

Roberts, J. (1998). *The Early Sessions: Book 4 of The Seth Material*. Manhasset, NY: New Awareness Network.

Roberts, J. (1999a). *The Early Sessions: Book 5 of The Seth Material* (p. 89, Session 211 on November 24, 1965). Manhasset, NY: New Awareness Network.

Roberts, J. (1999b). *The Early Sessions: Book 6 of The Seth Material.* Manhasset, NY: New Awareness Network.

Roberts, J. (2002). *The Early Sessions: Book 9 of The Seth Material* (Sessions 450 on November 20, 1968, and 510 on January 19, 1970). Manhasset, NY: New Awareness Network.

Saferstein, R. (1998). *Criminalistics: An Introduction to Forensic Science* (6th ed.). Prentice-Hall.

Schill, B. (2009). *21 grams: The weight of truth or deception?* Available at: http://www.iprfinc.com/brain11.html. Accessed 5 May 2009.

Stevenson, I. (1986). *Children Who Remember Previous Lives—A Question of Reincarnation.* Jefferson, NC: McFarland. (Revised ed. 2001)

Thigpen, C. H., & Cleckley, H. M. (1957). *The Three Faces of Eve.* McGraw-Hill.

Thompson, Sir Benjamin, Count of Rumford (1799). An inquiry concerning the weight ascribed to heat. *Philosophical Transactions of the Royal Society of London, 89,* 179−194. (Also in Brown, S. C. (Ed.), *Collected Works of Count Rumford*, Vol. 1, *Nature of Heat* (pp. 27−48), 1968, Belknap Press of Harvard University Press.)

Yamamoto, T., Suzuki, T., & Tasaki, K. (1988). *Modern Anatomy and Physiology* (p. 222) [Japanese]. Tokyo: Nan-e-do.