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Similarity Between Coffee Effects and *Qi*-Stimulating Events

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Abstract

Aims: Previously, we found that *qi*-stimulating events exerted similar frequency-specific effects on the blood pressure pulse spectrum. Because coffee and *qi* induce similar stimulatory psychological responses, we aimed to determine whether they would induce similar pulse effects. Such a relationship would suggest a close linkage between the physiologic mechanisms underlying the psychostimulatory responses and vascular effects of coffee and *qi*. Therefore, the profound investigations into the mechanisms underlying the effects of coffee on the central nervous system and the vascular system may help to elucidate the underlying physiology mechanisms of *qi*.

Methods: Each test subject took three rounds of 150 mL coffee (0.1 g/kg, 0.05 g/kg, 0.05 g/kg) in a 30-minute interval. The subject's pulses were recorded at the end of each round. The changes in the test subject's pulse spectrum between before and after coffee consumption were compared with changes induced by a water placebo.

Results: Both coffee and *qi* caused the intensities of the third, sixth, and ninth harmonics of the pressure pulse spectrum to be relative peaks to their neighboring harmonics.

Conclusion: Our results suggest that the coffee effect may be considered a *qi*-stimulating event, and there is a common physiologic factor determining the psychostimulatory responses of *qi* and coffee as well as their effects on the cardiovascular system, which results in a specific frequency pattern in the blood pulse spectrum. Adenosine, which is the main physiologic compound affected by coffee, might also be the key factor affected by *qi*.

Introduction

The concept of *qi* plays a very important role in Traditional Chinese Medicine. An energetic person is believed to have stronger *qi*, and consuming *qi*-related tonic herbs, applying acupuncture to the *qi*-related acupoint, and practicing *qigong* are all popular methods used to strengthen one's *qi*. Nonetheless, *qi* is still a mystery in modern science due to the lack of quantifiable measurement and scientific explications on its entity.

We previously conducted a series of studies aimed at solving this mystery, and found that Traditional Chinese Medicine is closely related to the frequency characteristics of the blood pressure pulse spectrum.[1–11] We observed that *qi*-stimulating events such as taking *qi*-related tonic herbs, applying acupuncture to the *qi*-related acupoint, or during movement *qigong* (not including meditative *qigong*) exerted similar frequency-specific effects on the blood pressure pulse spectrum. As shown in Figure 1, the *qi*-stimulating tonic herb *Ganoderma lucidum*[11,12] increases the intensity of the third (C3), sixth (C6), and ninth (C9) harmonics of the pressure pulse and causes them to be relative peaks to their neighboring harmonics, which is similar to the pattern of effects induced by applying acupuncture to the *qi*-related acupoint[7] *Tsu-San-Li* and during movement *qigong*.[2] However, the non-*qi*-related events, such as the prandial effect,[13] acupuncturing *Tai-Tsih*, an acupoint on the kidney meridian,[8] or taking the herbal formula *Liu-Wei-Dihuang*[10] all exerted distinct ef-

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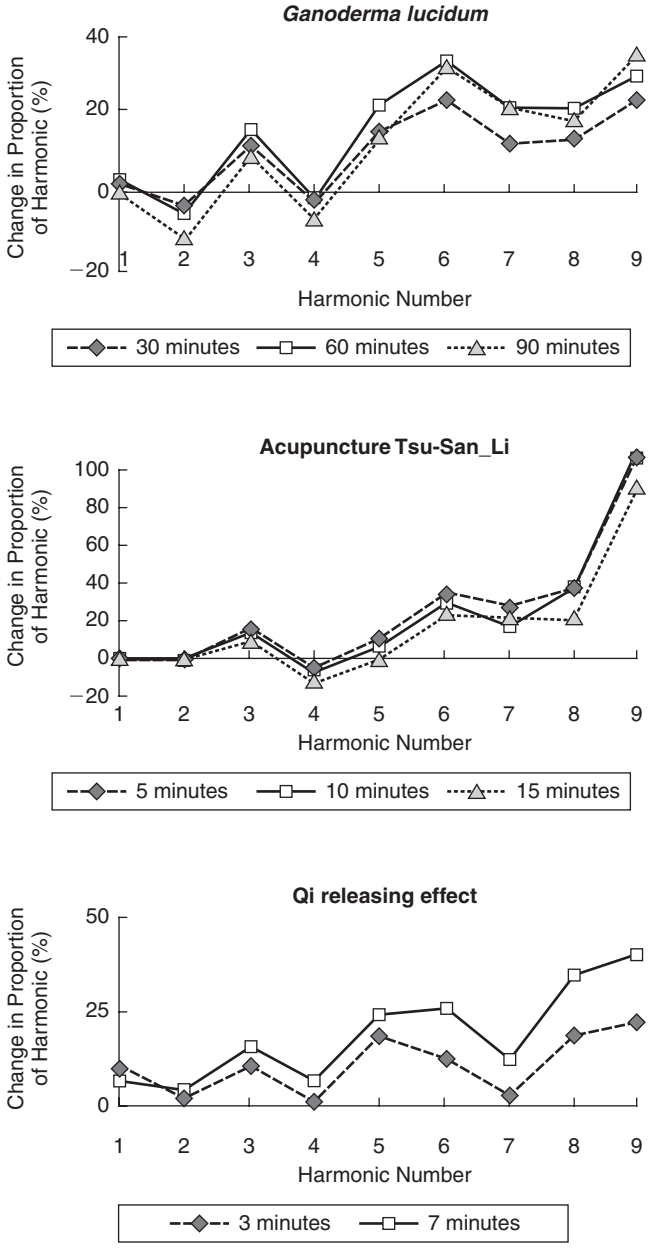

FIG. 1. Top: Effects of *Ganoderma lucidum* on the blood pressure pulse spectrum (replotted from Am J Chinese Med 22(2), pp. 199, 1994). The effects at 30, 60, and 90 minutes after administration of the herbal extract are presented as the percentage changes in the proportions of the harmonics relative to the before-herb control. **Middle:** Effects of acupuncture at *Tsu-San-Li* (from Am J Chinese Med 23 (2), pp. 124, 1995) after 15 minutes of needling. The effects at 5, 10, and 15 minutes after needling are presented as the percentage changes in the proportions of the harmonics relative to the before-needle control. **Bottom:** A typical *qi*-releasing effect pattern on pulse spectrum caused by a *qi-kung* master (from Biomedical Engineering: An International Symposium. Washington, DC: Hemisphere, 1989:268–297). The effects at 3 and 7 minutes after start-releasing *qi* are presented as the percentages changes in the proportions of the harmonics relative to the before-*qi* releasing control.

fect patterns on the blood pulse spectrum that were apparently different from the effect patterns of the above *qi*-stimulating events. Since each pattern of frequency-specific effects relates to the vascular conditions of a group of specific vascular beds,[3–5] these findings suggest that there are underlying physiologic factors that may cause the general *qi* performance and affect a specific group of vascular beds as well. These factors may influence the cardiovascular system in a specific way on specific vascular beds, and therefore cause frequency-specific *qi* patterns in the blood pulse spectrum. To reveal these *qi*-related physiologic factors will be the key in solving the mystery of *qi*.

Coffee is a widely used psychostimulant beverage. The main effects of coffee on the central nervous system (e.g., enhancing arousal, vigilance performance, and self-rated alertness, and reducing feelings of drowsiness and fatigue) are very similar to those associated with excitant *qi* performance.[14,15] If coffee would cause a similar frequency-specific *qi* effect pattern in the blood pulse spectrum, this indicates that the coffee effect may be considered a *qi*-stimulating event. It suggests that coffee and *qi* share the same underlying physiologic factors; and the profound investigations into the mechanisms underlying the effects of coffee on the central nervous system and the vascular system may help to elucidate the underlying physiology mechanisms of *qi*.

In this report, we studied the frequency-specific effects of coffee on the pulse spectrum and discussed the possible underlying physiologic factor of *qi*.

Materials and Methods

Experimental procedure

Twelve (12) human volunteer subjects (6 males, 6 females) aged 23–43 years and in apparent good health participated in this study. All of the subjects signed a consent form, and they were nonsmokers and were not habitual coffee, tea, or cola drinkers (less than 1 cup per day). The subjects were asked not to take any medications for 3 days before the experiments, and to abstain from consuming any alcoholic or caffeinated beverage 24 hours before the experiments.

The experiments were performed in a room maintained at 23–25°C. The detailed experimental profiles are shown in Figure 2.

Each subject was studied in the morning on 2 separate days. To minimize possible interference of daily activities on the pulse spectrum, such as prandial[13] or sleeping effects, we used day 1 as the water-placebo set to compare with the coffee set on day 2. On both days, a standard laboratory breakfast was provided that comprised one egg sausage muffin and 250 mL of warm soybean milk. Male subjects were also allowed to consume one hash brown if desired. The subject was asked to finish eating within 20 minutes, and the pressure pulses were recorded at 50 minutes after the first bite of food as the postbreakfast control.

Each test subject then consumed three servings of coffee (or equivalent volume of water): dose 1 at 0.1 g/kg and doses 2 and 3 at 0.05 g/kg, with each dose solved in 150 mL of 40°C water. The pressure pulses were recorded at 30 minutes after each servings of coffee (or water) as the postcoffee (or water) measurements.

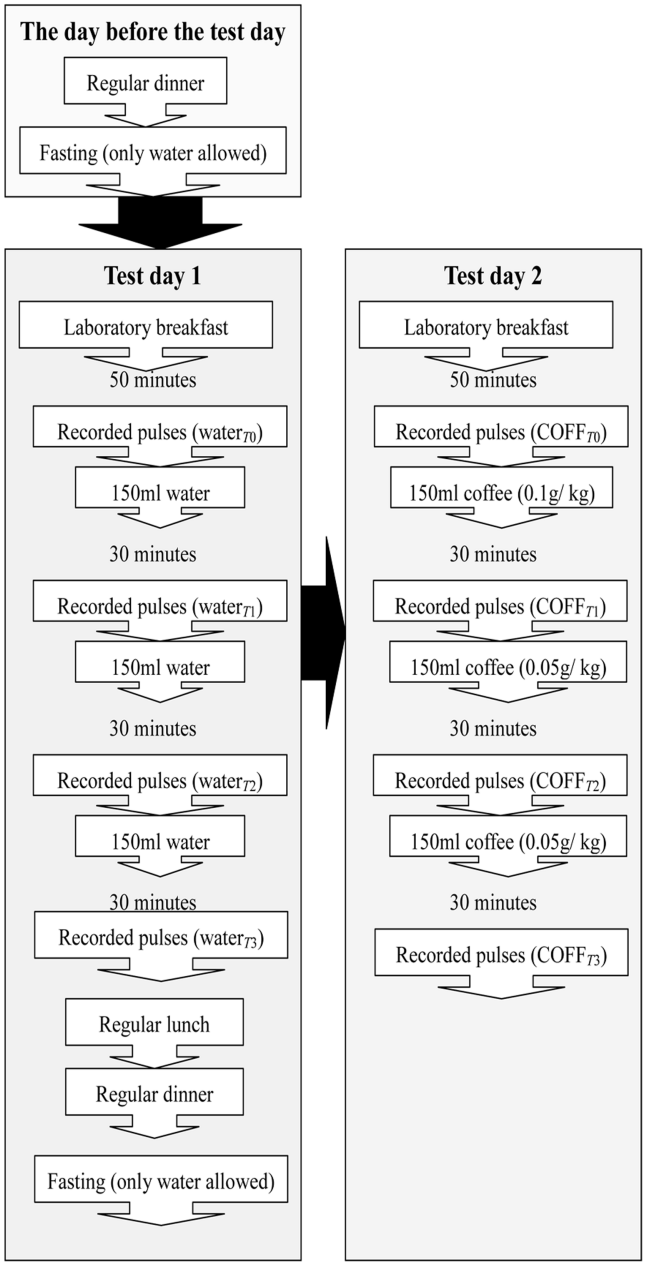

FIG. 2. Detail of experimental profiles.

Pressure pulses recording

Each subject was asked to lie down and relax with eyes open for 5 minutes. The pulse pressure was then recorded on the right-hand radial artery with a pressure transducer (PSL-300GL, Kyowa Electronic Instruments, Chofu, Japan) that was fixed on the skin by adhesive tape and an adjustable belt with a small button designed to exert the appropriate pressure on the transducer. About 60 consecutive pressure pulses were obtained during a 1-minute period.

Data processing

The output of the pressure transducer was connected to an IBM-compatible PC via an A-to-D converter with sampling rate of 430 data points per second. A periodical signal could be decomposed into sine waves (Fourier transform) with multiple frequencies ($n \times f_0$) of the fundamental frequency (f_0) of the signal; that is the spectrum of the signal.

The sine wave with $n \times f_0$ as its frequency is the n^{th} harmonic of the periodical signal. The pressure pulse is a periodical signal with heart rate as its fundamental frequency; the pulse spectrum was analyzed with Fourier transform software using one pulse as the period length. The standard deviation of the heart rate over each 1-minute recording period was not allowed to exceed 5%.

We defined the percentage change in the proportion of the n^{th} harmonic between the i^{th} serving of postcoffee (or water) measurements and the postbreakfast control as

$$(\%DIFF_{Ti}^{Cn}) = 100 \times \frac{Cn(Ti) - Cn(T0)}{Cn(T0)}$$

and net effect of the i^{th} serving of coffee on the n^{th} harmonic of the pressure pulse was calculated as

$$Coffee_{Ti}^{Cn} = (\%DIFF_{Ti}^{Cn})_{Coffee} - (\%DIFF_{Ti}^{Cn})_{Water}$$

where

$$Cn = \frac{An}{A0} \times 100\%$$

and Cn is the proportion of the n^{th} harmonic (n = 1–9), $T0$ is the postbreakfast control on day 1 or day 2, Ti is the i^{th} round of postcoffee (or water) measurements, An is the amplitude of the n^{th} harmonic of the pulse spectrum, and $A0$ is the DC value of the pressure pulse. Since the amplitudes of the harmonic waves (so the energy of the waves) of the pressure pulse are decreasing with its harmonic numbers, the amplitudes of the 10$^{\text{th}}$ and upper harmonic waves are very small and therefore could be neglected.

The averaged net effects of coffee ($Coffee_{Ti}^{Cn}$) and their standard errors for each postcoffee round were calculated. Student's paired t test was used for statistical comparisons.

Results

Table 1 lists the averaged post-breakfast control values on days 1 and 2 of the heart rate (HR), diastolic pressure (DP), systolic pressure (SP), and pulse height (SP-DP). None of these 4 physiologic indexes of the postbreakfast periods differed significantly between days 1 and 2.

Figure 3 shows the average effects of coffee (or water) on HR, DP, SP, and SP-DP at the end of the third-round postcoffee (or water) measurements presented as percentage changes relative to the postbreakfast control. The postprandial effect[13] resulted in the SP, DP, HR, and SP-DP being high at the postbreakfast control, and these values decreased monotonically with time from the postbreakfast control to the third-round postwater measurement on day 1. The high postbreakfast control DP and SP values remained high (or went even higher) after the third-round coffee measurement on day 2, indicating that coffee increased SP and DP. There were no significant differences between the coffee and water effects on HR and SP-DP.

The average net effect of coffee on the pressure spectrum is shown in Figure 4, which shows peaks for the third, sixth and ninth harmonics in 60-and 90-minute measures (i.e., the effects of the third, sixth, and ninth harmonics are higher than the effects of their neighboring harmonics). Coffee also

Table 1. Averaged Postbreakfast Control Values ($N = 12$) on Days 1 and 2 of Systolic Pressure (SP), Diastolic Pressure (DP), Heart Rate (HR) and Pulse Height (SD-DP)

	SP (mm Hg)	*DP (mm Hg)*	*HR (beats minute^{-1})*	*SP-DP (mm Hg)*
Day 1	103 ± 2.8	64 ± 2.1	75 ± 2.3	39 ± 3.1
Day 2	105 ± 3.6	64 ± 2.7	77 ± 2.5	42 ± 2.5

Data are mean ± standard error values.

increased the first harmonic but decreased the second and fourth harmonics. The net effects of coffee increased with time due to the accumulated doses. The coffee effect may be small and not well established in 30-minute measures yet; therefore, it is the large errors of the higher harmonics that may obscure the small effect pattern in the 30-minute measures. After dosage accumulations, the coffee effects become larger and larger; the similarities between coffee effect and *qi*-stimulating events effects become apparent.

Discussions

The main effects of coffee on the central nervous system (e.g., enhancing arousal, vigilance performance, and self-rated alertness, and reducing feelings of drowsiness and fatigue)[14,15] are very similar to those associated with excitant *qi* performance. In this study, we found that coffee and *qi* also exerted similar frequency-specific effects on the blood pulse spectrum.

Drinking coffee (Fig. 4), consuming *qi*-stimulating tonic herbs (Fig. 1, top), applying acupuncture to the *qi*-related acupoint (Fig. 1, middle), and during movement *qigong* (Fig. 1, bottom) all caused the intensities of the third, sixth, and ninth harmonics of the pressure pulse spectrum to be relative peaks to their neighboring harmonics. Since each pattern of frequency-specific effects relates to the vascular conditions of a group of specific vascular beds, our study suggests that the *qi*-stimulating events and coffee affect the same group of specific vascular beds. It indicates that the same physiologic factor underlies the effects of coffee and *qi* performance (in terms of the specific effects on the cardiovascular system), which therefore have similar frequency-specific effects on the pulse spectrum.

Under normal physiologic conditions, the primary biologic effect of caffeine (one of the major physiologically active components of coffee) is competitive antagonism of the adenosine receptor.[15–17] Adenosine is a normal cellular constituent that can dilate multiple vascular beds.[18] The presence of presynaptic adenosine A1 receptors mediating inhibition of transmitter release (mostly the excitatory transmitters) has been demonstrated on virtually all types of neurons.[19] Blocking the adenosine receptors or decreasing the adenosine concentration can stimulate the central nervous system and vasoconstriction effects on specific vascular beds, and thereby induce frequency-specific effects on the pulse spectrum.

Adenosine links the coffee effects on the pulse spectrum and the coffee responses on the central nervous system. The same adenosine linkage may also exist between the *qi* effects on pulse spectrum and the *qi* responses on the central nervous system.

The relative rates of ATP breakdown and synthesis are the main factors determining the rate of adenosine formation.

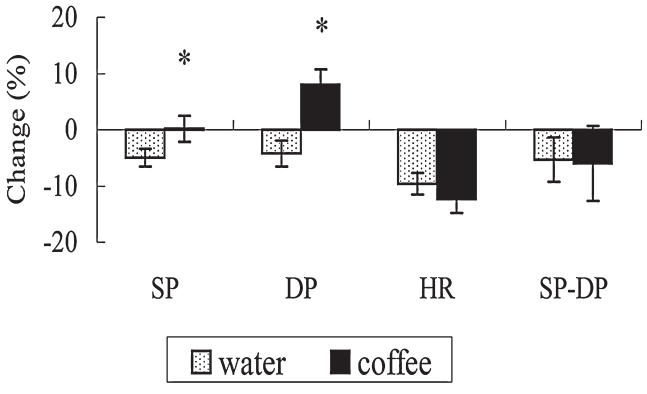

FIG. 3. Effects ($n = 12$) of water and coffee on systolic pressure (SP), diastolic pressure (DP), heart rate (HR), and pulse height (SP-DP). The average third-round postcoffee (or water) effects are presented as percentage changes relative to the postbreakfast controls. The error bars indicate standard errors. The asterisk indicates that the coffee effect differs significantly ($p < 0.05$) from the water effect.

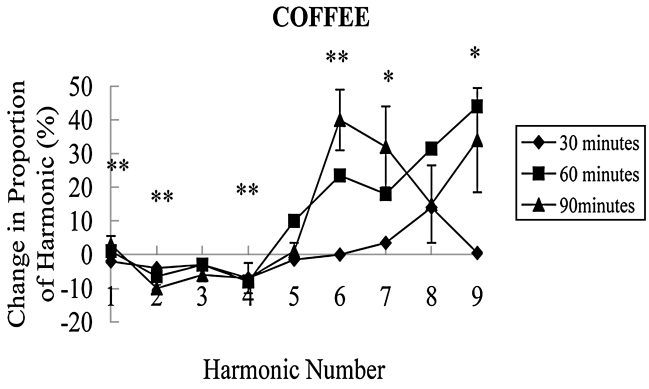

FIG. 4. Net effects (postcoffee variations minus postwater variations) of coffee ($n = 12$) on blood pressure pulse spectrum. The 30-, 60-, and 90-minute postcoffee (postwater) effects were calculated as the percentage changes in the proportions of the harmonics relative to the postbreakfast control. The error bars indicate standard errors. Single and double asterisks indicate that the net effect of coffee differs significantly ($p < 0.1$ and $p < 0.01$, respectively) from zero.

These mechanisms are in turn determined by the rate of energy utilization and the availability of metabolizable substrate.[15,16] *Qi* is related to the energy utilization. An energetic person is believed to have stronger *qi*; the *qi* deficiency may result from hypoxia due to conditions such as a weak heart, poor lung function, ischemia, poor peripheral circulation, or aging. There is evidence that the level of adenosine increases by about threefold following mild hypoxia and that the level of adenosine can increase dramatically to 10 μmol/L or more following ischemia.[20,21] As a consequence, the adenosine level increases with hypoxia; this inhibits the release of neuron transmitters and many central nervous functions as described as *qi* deficiency symptoms. Song and Liang[22] reported that the *qi*-tonifying herbal compounds *Fu Jiang* and *Shen Qi* may increase norepinephrine and dopamine but decrease the amount of serotonin in the brain, and both compounds could excite sympathetic nerves and the endocrine system in the peripheral and central nervous systems. Sun[23] reported that the levels of ATP in the skeletal muscle are significantly lower and anaerobic glycolysis is higher in rats with spleen *qi*-deficiency syndrome than in normal rats. These symptoms could be corrected after treatment with *Si-junzi Tang* for strengthening spleen and tonifying *qi*. Ko et al.[24] pointed out that the *qi*-invigorating herbs, *Radix glycyrrhizae* and Radix astragali, can enhance myocardial ATP-generation capacity.

These studies strongly support our hypothesis that adenosine is probably the implicit key factor of *qi*. The efficacy of all methods for improving *qi* may be related to their ability to increase ATP synthesis or to decrease adenosine functions. This implies that all *qi*-stimulating events increase the perceived energy level by exciting the nervous system, with the effects on specific vascular beds resulting in frequency-specific patterns in the blood pulse spectrum.

In this report, the pulse effect on *qigong* study was conducted during movement *qigong*. The static *qigong* (meditation) may be different. During meditation, a person is relaxed and calm, which is dissimilar to the movement *qigong* or coffee effect.

Conclusion

The effects of coffee and *qi* are related based on their similar psychostimulatory responses on central nervous system and frequency-specific effects on the pulse spectrum. Although further studies are needed to prove our hypotheses, this study suggests the possible underlying physiologic processes and the determining factor of *qi*. The profound knowledge on coffee studies may provide useful hints to reveal the mystery of *qi*.

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Disclosure Statement

No competing financial interests exist.

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