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Cognitive and Physiological Effects of Falun Gong Qigong

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Cognitive and Physiological Effects of Falun Gong Qigong

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in Psychology

By

Benjamin Warren Bendig

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ABSTRACT OF THE DISSERTATION

Cognitive and Physiological Effects of Falun Gong Qigong

by

Benjamin Warren Bendig

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2013

Professor Patricia Cheng, Co-chair

Professor David Shapiro, Co-chair

This dissertation examines 1) baseline cognitive, physiological, and psychological differences between Falun Gong (FLG) practitioners and novices and 2) acute cognitive, physiological, and psychological effects after a 91-minute sequence of the FLG qigong exercises in 22 experienced FLG practitioners and 17 novices. We employed a Lateralized Attention Network Task (LANT) that measures conflict resolution and spatial orienting in each hemisphere. FLG practitioners showed an advantage in accuracy for both interhemispheric and right-hemisphere trials, as well as differences compared to novices in emotional processing. Both groups improved in overall reaction time on the attention task and on a coordination task after practicing the FLG exercises. Furthermore, there was an overall improvement in positive and energy/arousal moods for both groups, and novices had reduced negative mood after the exercises. Both groups acutely increased sympathetic activity, as measured by skin conductance and the ratio of low frequency to high frequency heart rate variability. Positive correlations of changes in accuracy in the right hemisphere with changes in both skin

conductance and high-frequency heart rate variability suggest that for practitioners, cognitive improvement from pre- to post-FLG can be attributed to the FLG exercises, and at the same time suggest an important psychophysiological relationship concerning chronic effects of FLG and the right hemisphere of the brain. Changes in high-frequency heart rate variability also positively correlated with changes in reaction time. Skin conductance did not correlate with any changes in reaction time, but values pre- and post-FLG are negatively correlated with reaction time. Correlations between amount of FLG practice and depression, anxiety, sleep quality, and mood suggest that regular practice of the FLG exercises and associated activities can provide a number of long-term psychological benefits.

The dissertation of Benjamin Warren Bendig is approved.

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To the world. I hope this helps.

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Paper 1

Physiological and Psychological Effects of Falun Gong Qigong

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Abstract

This study examines 1) baseline psychological and physiological differences between Falun Gong practitioners and novices and 2) acute physiological effects after a 91-minute session of the Falun Gong qigong exercises. Data were obtained from 17 experienced Falun Gong (FLG) practitioners and 14 novices. After practicing the FLG exercises, there was an overall improvement in positive and energy/arousal moods for both groups, and novices had reduced negative mood. Both groups increased sympathetic activity, as measured by skin conductance and the ratio of low frequency to high frequency heart rate variability. Correlations between amount of regular FLG practice and depression, anxiety, sleep quality, and mood suggest that the FLG exercises and associated activities can provide a number of benefits.

Physiological and Psychological Effects of Falun Gong Qigong

Qigong is a family of "movement meditation" practices originating in China, which involve slow deliberate movements and aspects of meditation (Larkey, Jahnke, Etnier, & Gonzalez, 2009). Like yoga, it is thought these practices are helpful for health and wellness (Jahnke, Larkey, Rogers, Etnier, & Lin, 2010), improving immune function (Lee et al., 2003; Li, Li, Garcia, Johnson, & Feng, 2005), physiological functions (e.g., Lee et al., 2002), sleep (Manzaneque et al., 2009), and mood (Johansson, Hassmen, & Jouper, 2008). Tai Chi is considered a form of qigong (Larkey et al., 2009) and enjoys wide popularity, but the most popular qigong practice in China was at one time Falun Gong (FLG). After being introduced to the Chinese public in 1992, FLG grew to an estimated 70–100 million practitioners by 1999 (The Epoch Times, 2004). One reason for its popularity is thought to be reports of remarkable transformations of health that happen after practicing (Dan, 1998; Minghui, 2008; The Epoch Times, 2004). FLG has been the subject of little research, however, with only one journal publication in English (Li et al., 2005). In China, research related to FLG is discouraged or punished by the government, unless it agrees with the government's persecution and propaganda campaign instituted in 1999, which aims to "eradicate" the practice (The Epoch Times, 2004).

Typically, FLG practitioners perform the exercises while focusing on special music created for the practice, often outdoors in groups. The movements are standardized and include gentle stretching, slow movement, and postures that are held for extended periods of time while the eyes are closed. Practitioners do not direct their thinking toward anything during practice with the exception of the music, so there is no focus on the breath or any deliberate mental activity such as reciting a mantra (Li, 2003). In FLG, the exercises are part of a larger spiritual discipline that is based on improving oneself in accord with the principles of truthfulness, compassion, and forbearance (Li, 2000).

Studies on the physiological processes in qigong and meditation have shown baseline differences between practitioners and controls, revealing that practitioners have better immune function (e.g., Li et al., 2005), better cognitive performance (e.g., Moore & Malinowski, 2009), and various health benefits (e.g., Klein & Adams, 2004). In addition to baseline differences, also of interest are acute effects (i.e., the observed difference before and after an intervention). Acute effects of qigong and Tai Chi have been found for decreased sympathetic activity (Motivala, Sollers, Thayer, & Irwin, 2006; Tang et al., 2007), increased parasympathetic activity (Tang et al., 2007), and increased immune activity (Lee et al., 2003). Acute effects are potentially important because they can be informative of long-term changes resulting from regular practice, free from possible self-selection bias of practitioners. It is still possible that the observed baseline differences between practitioners and others are due to the practitioners choosing the practice because they especially benefit from it. However, acute benefits would suggest that the differences between groups result from the practice, rather than reflect a prior difference between groups.

Psychological benefits have been reported for qigong and other forms of movement meditation, such as acute improvement of mood for yoga (Shapiro et al., 2007) and for qigong (Johansson et al., 2008; Kimura et al., 2005), as well as long-term improvements in mood for qigong (Manzaneque et al., 2009; Oh et al., 2010). Anti-depressive effects (Tsang & Fung, 2008), improved sleep quality (Jahnke, Larkey, & Rogers, 2010; Manzaneque et al., 2009), and reduced anxiety (Johansson et al., 2008; Manzaneque et al., 2009; Oh et al., 2010) have also been found.

Research Objectives and Design

The purpose of this article is to present data on the acute psychological and physiological effects of practicing FLG, comparing differences between practitioners and novices. We employed a before-and-after design. Experienced FLG practitioners performed the FLG qigong exercises between undergoing physiological measurements and performing a number of cognitive tasks (reported elsewhere). A comparison group of novices underwent the same assessments and performed a slightly abridged version of the FLG exercises. The acute effects of a single session were measured. Baseline differences could also be compared to assess possible long-term effects of practicing FLG.

Hypotheses

Physiological Effects. Previous research has largely focused on the difference between practitioners performing the intervention of interest and other subjects undergoing an alternate, control intervention (e.g., Motivala et al., 2006; Tang et al., 2007). In this study, because both groups are performing the same intervention, it allows the testing of different hypotheses about the acute effects of FLG. According to the "experience" hypothesis, the exercises should have larger acute effects for practitioners because they are presumably better at performing them than novices. By contrast, the "optimality" hypothesis predicts that while practitioners are better at doing the exercises, they have also chronically accrued the benefits of the exercises. They would have less room to change than novices, therefore showing smaller acute effects, but larger differences between groups at baseline. A third possibility is that the exercises will benefit both groups equally.

Because FLG encourages relaxation and the reduction of stress, it is expected that sympathetic activity, considered an index of arousal and part of the stress response (Sherwood, 2012), should reduce for after practice. This has been shown acutely in previous Tai Chi (Motivala et al., 2006) and qigong (Tang et al., 2007) research. Furthermore, parasympathetic activity, which complements the sympathetic nervous system and is involved in restful states (Sherwood, 2012), should increase after practice. Previous meditation and qigong research has demonstrated the acute increase of parasympathetic activity as a result of practice (Takahashi et al., 2005; Tang et al., 2007; Wu & Lo, 2008).

For both sympathetic and parasympathetic changes, we would expect different patterns of results based on the above three hypotheses: 1) for the "experience" hypothesis, practitioners and novices will not differ at baseline, but practitioners will show larger changes than novices, hence there will be no main effect of Group, but a significant Group by Pre/Post-exercise interaction; 2) for "optimality," the groups will differ at baseline, but novices will show larger changes than practitioners, producing a main effect of Group, as well as a Group by Pre/Post-exercise interaction; and 3) if the exercises benefit both groups equally, there will be a main effect of Pre/Post-exercise, but no main effect of Group and no Group by Pre/Post-exercise interaction.

Psychological Effects. Based on reports from practitioners and movement meditation research in general (e.g., Johansson et al., 2008; Kimura et al., 2005; Shapiro et al., 2007), positive mood and energy/arousal mood ratings are predicted to acutely increase, and negative mood ratings to acutely decrease after practice for both groups. Novices may feel best mid-session because the length of the session may be tiring. If effects were shown for novices, it would go beyond previous work for movement meditation, demonstrating that the initial session can improve mood. Practitioners are expected to report fewer symptoms of illness than novices, based on research showing improved immune function in FLG practitioners (Li et al., 2005). Additionally, practitioners should report better sleep and reduced anxiety and depression compared to novices.

Methods

Participants

Table 1.1 lists the demographic details for participants with complete data for both the FLG-practitioner group and the novice group.

FLG practitioners. Twenty-four experienced FLG practitioners were recruited, but a total of 17 with complete data were included (6 male, 11 female; 6 white, 11 Asian). Practitioners' average age was 44.6 years. Practitioners were recruited through contacts of the author and other participants. See Table 1.2 for details on amount of time spent on FLG activities. Among practitioners in the sample, normal practice of the exercises occurs both alone and in groups. For all participants, exclusions were: BMI must be below 33, no physical limitations that might preclude doing the exercises, no medications that might affect the physiological measures, and no self-reported psychiatric conditions.

Novices. Twenty-four novices were recruited through advertisements on craigslist.com, newspaper ads, and UCLA staff mailing lists, 14 of whom had complete data (10 male, 4 female; 5 white, 3 Asian, 4 Hispanic, 2 African-American). Novices' average age was 42.6 years. Exclusion criteria for novices were: no prior experience with FLG, a maximum of three months with other qigong or meditation practices within the last 5 years, and not currently practicing. Four novices reported having some meditation experience, but none recently. The recruiting was targeted toward people interested in FLG.

Participants in both groups were compensated $45 and parking was reimbursed. One practitioner did not accept payment.

Table 1.1. Demographic information for participants.

Demographics		Practitioners	Novices
Gender	Male	6	10
	Female	11	4
	Age (years)	44.6 (31–65)	42.6 (27–61)
Ethnicity	White	6	5
	Asian	11	3
	Hispanic	0	4
	African American	0	2
	Mixed	0	0
	Education (years)	17.1 (10–23)	15.5 (10–23)
Work	Professional/technical	10	8
	Blue collar	1	3
	Helper/assistant	2	0
	Student	1	1
	Retired	0	1
	Unemployed/housewife	3	1
	Full time	12	5
	Part time	3	7
	Exercise (hours/week)	4.5 (0–17)	12.6 (0–29)
Menstrual status	Regular	6	2
	Post-menopausal	3	1
	Birth control	0	2

Table 1.2. Statistics on amount of time spent on FLG activities

Amount of FLG Practice	Mean	Range
Years practiced	9.4	2–17
Exercise frequency (hours/week)	9.6	4–14
Time spent reading FLG literature (minutes/day)	67.9	15–150

Procedure

The procedure described is for an entire study that also included cognitive tasks[1], however this paper pertains only to the physiological and psychological results. Participants went to the UCLA Psychophysiology Lab on two separate days, within a span of two weeks. All subjects were run individually, and came at approximately the same time of day for both sessions. Practitioners were asked not to perform the FLG exercises prior to the visit on either day. The first day subjects

[1] As part of the dissertation requirement for a Ph.D.

signed the consent form, filled out questionnaires, and then performed cognitive tasks. On the second day, subjects 1) filled out a questionnaire, 2) underwent physiological recordings, 3) performed the FLG exercises, 4) again had their physiological measures recorded, and 5) performed the same cognitive tasks as in the first session, in the same order. Mood questionnaires were administered immediately before, mid-session at the 1-hour point, and immediately after the exercises were performed. After completing the cognitive measures, participants were debriefed, paid, and thanked. See Table 1.3 for order and duration of the different tasks and procedures for both days.

Table 1.3. Breakdown of the procedure for both days, with time for each step.

Overall Procedure			
Day 1		**Day 2**	
Consent	5 min	Questionnaire (PANAS)	3 min
Questionnaires	25 min	Setup	5 min
Attention task	30 min	Physiological recordings	15 min
Coordination task	5 min	Mood questionnaire #1	2 min
Working memory task	10 min	FLG standing exercises	60 min
		Mood questionnaire #2	2 min
		FLG sitting exercise	31 min
		Mood questionnaire #3	2 min
		Setup	5 min
		Physiological recordings	15 min
		Attention task	30 min
		Coordination task	5 min
		Working memory task	10 min
		Debriefing and payment	5 min
Total:	**75 min**		**190 min**

Practitioners performed 91 minutes of the exercises, and novices performed 76 minutes, plus 15 minutes of instruction in which they also carried out some of the movements (see Table 1.4 for details on the exercises and times). The exercises were performed along with a recording of Chinese music with FLG's founder calling out positions and movements in Mandarin. This allows practitioners to perform the exercises in sync without needing to look at others. The author performed the exercises along with the experienced participants. The author also taught and performed the exercises along with the novices, allowing for a minimum of corrections, which might otherwise disrupt the participants. Participants could observe what the instructor was doing without having to inquire in the case of uncertainty or a lapse of memory.

Table 1.4. Breakdown and physical description of the FLG exercises. Complete descriptions and videos of the exercises can be found at www.falundafa.org.

Falun Gong Exercises			
Practitioners		**Novices**	
		Instruction	15 min
Standing exercises	**1 hour**	**Standing exercises**	**45 min**
1st: gentle stretching	10 min	1st: gentle stretching	10 min
2nd: Four "wheel holding" postures	30 min	2nd: Four "wheel holding" postures	15 min
3rd: slow arm movements	8 min	3rd: slow arm movements	8 min
4th: slow movements around the body	12 min	4th: slow movements around the body	12 min
Sitting meditation	**31 min**	**Sitting meditation**	**31 min**
Arm movements	1 min	Arm movements	1 min
Arms held out	5 min	Arms held out	5 min
Arm held below chin	5 min	Arm held below chin	5 min
Other arm below chin	5 min	Other arm below chin	5 min
Hands held in lap	15 min	Hands held in lap	15 min
Total:	91 min		91 min

Assessments and Stimuli

Physiological Measures. All measurements were made in a soundproof room, taken in the resting state for 15 minutes both before and after FLG. A Biopac data acquisition system (Goleta, CA) was used for the measurements. A custom Matlab program was used to process the data.

Physiological measures for both pre- and post-FLG were averaged over the 15-minute recording. Artifacts were removed prior to analysis.

Heart Rate and Heart Rate Variability. Electrodes (Biopac EL503, AgCl, 1 cm diameter contact, 7% chloride solution) were placed above the right and below the left side of the heart (Lead 2 configuration); sites were slightly abraded and cleaned using alcohol. Heart rate variability measures were derived from the electrocardiogram (ECG) data using Kubios Heart Rate Variability software (Biosignal Analysis and Medical Imaging Group at the Department of Applied Physics, University of Kuopio, Kuopio, Finland), using the fast Fourier transform spectrum, taking 2-minute intervals. Heart rate variability (HRV) examines low frequency (LF) power (.04–.15 Hz) and high frequency (HF) power (.15–.40 Hz) components using the serial interbeat intervals with msec accuracy. LF-HRV and HF-HRF are reported in ms^2, and are also converted into normalized units by dividing the power of each by the total of LF-HRV and HF-HRV power. From these normalized units, the ratio of LF (n.u.) over HF (n.u.) was also calculated. The HF spectrum is considered a measure of parasympathetic activity (Akselrod et al., 1981) and LF spectrum a combination of both sympathetic and parasympathetic activity (Appel, Berger, Saul, Smith, & Cohen, 1989). LF/HF-HRV is a measure of sympathetic/parasympathetic balance, with higher values indicating greater sympathetic activity. Heart rate variability was analyzed in two-minute segments. Values were all transformed by the natural logarithm.

Skin Conductance. SC was measured using the constant voltage method with disposable Ag-AgCl electrodes with a 1 cm diameter contact area (Biopac EL507) placed on the volar surfaces of two fingers of the left hand. The electrodes were pretreated with .5% chloride contact medium and were replaced each time.

Questionnaires. Subjects filled out the PANAS (Positive Affect Negative Affect Schedule) mood inventory (Watson, Clark, & Tellegen, 1988) at the beginning of both sessions. Five other questionnaires were administered: The PSQI (Pittsburgh Sleep Quality Index); the Center for Epidemiologic Studies Depression Scale (CES-D) as a measure of depressive symptoms (Radloff, 1977); the Pennebaker Inventory of Limbic Languidness (PILL) (Pennebaker, 1982) as a measure of reported symptoms of illness over the past six months; the Spielberger Trait Anxiety Inventory (STAI) as a measure of state and dispositional anxiety (Spielberger, Gorsuch, & Lushene, 1970); and a questionnaire for demographic information, including education, amount of exercise, physical activity per week, and socioeconomic status. FLG practitioners completed an additional questionnaire about how often they practice the exercises, how many years they have practiced, and how much time per day they spend studying FLG literature.

The mood questionnaire administered before, during, and after the FLG session consisted of five postive moods (happy, relaxed, optimistic, confident, content), nine negative moods (stressed, sad, frustrated, irritated, depressed, anxious, blue, angry, pessimistic), and six energy-related moods (attentive, fatigued, alert, tired, energetic, sleepy), rated on a scale from 1 (not at all) to 5 (very much).

Written translations into Chinese were prepared for practitioners who were not comfortable answering questions in English. The PSQI was not translated.

Data Analysis

The physiological measures were each analyzed separately using ANOVA, which used Pre/post-exercise and Group as factors, and t-tests were used to examine differences between groups. The measures included: heart rate, skin conductance, low-frequency HRV, high-frequency HRV, low-frequency HRV (normalized units), high-frequency HRV (normalized units), and the ratio of low-frequency HRV (n.u.) to high-frequency HRV (n.u.). Analyses were also completed using gender as an additional factor, but because it did not lead to any significant interactions, it was not included in the final analyses. Ethnicity was not used as a factor because of the difference in composition between groups, and low numbers of different ethnicities in the novice group.

Questionnaire scores for the PSQI, STAI, CES-D, and PILL were analyzed with independent groups t-tests. The PANAS was analyzed with ANOVA using Group and Pre/post-execise as factors, as well as t-tests to determine differences for a given session. Mood questionnaires were analyzed with ANOVA, using Period (pre, mid, and post) and Group as factors, and t-tests to determine group differences. Correlations were also examined, using Pearson's r, for practitioners' years of practice of FLG, hours per week of practicing the FLG exercises, and minutes per day of reading the FLG texts with questionnaire results for PANAS, STAI, CES-D, PILL, PSQI, and mood.

Results

For the present analysis, alpha equal to .05 is considered significant.

Physiological Measures

Heart rate. No significant differences were found for Group (F (1,29) = .29, p = .60), Pre/post-exercise (F (1,29) = 1.84, p = .19) or Group by Pre/post-exercise (F (1,29) = .23, p = .64).

Skin Conductance. Equipment failures led to one novice missing 3 minutes of data, and another missing 9 minutes. No overall group difference was found (F (1,29) = .196, p = .661), but a Pre/post-exercise effect was found for both groups (F (1,29) = 8.68, p = .006), indicating SC levels went up after practicing FLG (pre: M = 3.80, SD = 3.26; post: M = 5.21, SD = 4.36). No Group by Pre/post-exercise effect was found (F (1,29) = 1.61, p = .22). See Table 1.5 for a summary of SC results.

Table 1.5. Summary of skin conductance results.

SC (μS)	Pre	Post	**Pre/post**
Practitioners	3.8	4.7	*n.s.*
Novices	3.8	5.9	*0.016*
Group	*n.s.*	*n.s.*	*n.s.*

Heart Rate Variability. No group differences were found for LF-HRV (F (1,25) = .995, p = 3.27), but there was an effect of Pre/post-exercise (F (1,29) = 6.72, p = .015), with levels increasing from pre (M = 5.82, SD = .996) to post (M = 6.13, SD = .81). The Group by Pre/post-exercise effect was not significant (F (1,29) = .02, p = .89).

No differences were found for HF-HRV for Group (F (1,29) = .18, p = .67), Pre/post-exercise (F (1,29) = 2.17, p = .15), or Group by Pre/post-exercise (F (1,29) = .006, p = .94).

An effect of Pre/post-exercise was found for LF-HRV (n.u.) (F (1,29) = 6.05, p = .02), with values increasing (pre: M = .513, SD = .040; post: M = .524, SD = .037) but no main effect of Group was found (F (1,29) = .14, p = .72) and no interaction of Group by Pre/post-exercise (F (1,29) = .013, p = .91).

HF-HRV (n.u) showed an effect of Pre/post-exercise (F (1,29) = 6.05, p = .02), with values decreasing (pre: M = .486, SD = .040; M = .476, SD = .037), and no main effect of Group (F (1,29) = .14, p = .72) or interaction of Group by Pre/post-exercise (F (1,29) = .013, p = .91).

LF/HF (n.u.) was significant for Pre/post-exercise (F (1,29) = 6.19, p = .019, with values increasing (pre: M = 1.07, SD = .17; post: M = 1.11, SD = .17), but no significant effects for Group (F (1,29) = .23, p = .63) or Group by Pre/post-exercise (F (1,29) = .004, p = .947) were found. See Table 1.6 for a summary of HRV results.

Table 1.6. Summary of HRV results.

LF-HRV	Pre	Post	**Pre/post**
Practitioners	5.67	6.00	*n.s.*
Novices	5.99	6.29	*n.s.*
Group	*n.s.*	*n.s.*	*n.s.*

HF-HRV	Pre	Post	**Pre/post**
Practitioners	5.41	5.54	*n.s.*
Novices	5.55	5.67	*n.s.*
Group	*n.s.*	*n.s.*	*n.s.*

LF-HRV (n.u.)	Pre	Post	**Pre/post**
Practitioners	0.511	0.522	*n.s.*
Novices	0.517	0.526	*n.s.*
Group	*n.s.*	*n.s.*	*n.s.*

HF-HRV (n.u.)	Pre	Post	**Pre/post**
Practitioners	0.489	0.478	*n.s.*
Novices	0.483	0.474	*n.s.*
Group	*n.s.*	*n.s.*	*n.s.*

LF/HF-HRV (n.u.)	Pre	Post	**Pre/post**
Practitioners	1.057	1.099	*n.s.*
Novices	1.087	1.127	*n.s.*
Group	*n.s.*	*n.s.*	*n.s.*

Questionnaires

No significant differences were found on the STAI for state anxiety (t (29) = 1.38, p = .18) or trait anxiety (t (29) = .85, p = .40). No difference was found between the groups for the PILL (t

(29) = 1.06, p = .30). One novice did not fill out the CES-D. No difference was found between groups on this scale (t (28) = .98, p = .34).

Two practitioners did not complete the PSQI because there was no version available in Chinese, and another practitioner did not fully complete the questionnaire. No difference was found for the PSQI overall (t (26) = .232, p = .82), but a difference was found in sleep latency between the groups (t (27) = 2.1, p = .048).

The PANAS showed no overall difference between the groups for positive emotions (F (1,29) = 1.73, p = .20) or negative emotions (F (1,29) = 2.69, p = .11). For a summary of the questionnaire results, see Tables 1.7 and 1.8.

Table 1.7. Summary of PANAS scores from both visits.

	PANAS			
	Positive		Negative	
	1st session	*2nd session*	*1st session*	*2nd session*
Practitioners	45.2	39.8	15.9	16.1
Novices	47.4	49.0	19.8	18.0
Group	***n.s.***	***.05***	***n.s.***	***n.s.***

Table 1.8. Summary of questionnaire data.

	PSQI		**PILL**	**STAI**		**CES-D**
	Overall	*Sleep onset*		*State*	*Trait*	
Practitioners	3.43	8.6 min	31.5	28.5	34.9	7.7
Novices	3.64	26.1 min	61.4	34.4	37.8	9.9
Group	**n.s.**	**0.048**	**n.s.**	**n.s.**	**n.s.**	**n.s.**

Mood Ratings. Three practitioners and three novices did not have complete data for the mood ratings. See Table 1.9 for results of the mood questionnaires administered before, during, and after the FLG session. For overall energy ratings, negatively valenced moods were reverse scored (e.g., a 1 on "fatigued" was counted as a 5). T-tests were used to compare pre- to mid-session, mid- to post-session, and pre- to post-session moods. Analysis with ANOVA by Period found that positive mood increased (F (2,46) = 8.23, p = .001) and energy/arousal moods increased (F (2,46) = 20.22, p < .001) for both groups. Negative mood, however, did not change overall across groups (F

(2,46) = 2.08, p = .136). A Group by Period interaction (F (2,54) = 4.54, p = .016) was found for energy/arousal moods, where practitioners show increasing energy across periods, and novices show a peak mid-session.

Table 1.9. Mood ratings by group.

	Practitioners			Novices		
	Positive	**Negative**	**Energy**	**Positive**	**Negative**	**Energy**
Pre	3.23	1.36	3.27	3.70	1.52	3.67
Mid	3.55	1.31	4.05	3.93	1.57	4.12
Post	3.79	1.30	4.21	3.92	1.35	3.94
Pre-mid	*.013*	*n.s.*	*< .001*	*n.s.*	*n.s.*	*n.s.*
Mid-post	*n.s.*	*n.s.*	*.038*	*n.s.*	*n.s.*	*n.s.*
Pre-post	*.003*	*n.s.*	*< .001*	*n.s.*	*.014*	*.001*

Correlations

For practitioners, the amount of time studying the FLG texts per day correlates with sleep quality (r = -.56, p = .038) (lower scores are better on the PSQI). Years of practice correlates with PANAS positive scores for the first day (r = .62, p = .008) and energy/arousal moods at the beginning of the FLG session (r = .55, p = .043). Hours per week of practice is also negatively correlated with trait anxiety scores (r = -.57, p = .017) and depression scores (r = -.49, p = .045), such that the more hours practiced per week, the lower the anxiety and depression scores.

Discussion

This study demonstrated that the Falun Gong (FLG) qigong exercises have acute effects on mood and physiology, and that amount of FLG practice is associated with psychological benefits. The FLG exercises acutely increase positive mood for practitioners, increase subjective energy for both practitioners and novices, and decrease negative mood for novices, as well as increase sympathetic activity in both groups. Amount of time spent reading the FLG texts is associated with better sleep, and years of practice is associated with better mood and higher energy/arousal ratings, and hours per week practicing the exercises predicts lower anxiety and depression scores.

Acute Effects

The physiological findings went against predictions that parasympathetic activity would increase and sympathetic activity would decrease in practitioners after the FLG exercises. Both groups showed greater sympathetic activity after practice, as evidenced by an increased sympathetic/parasympathetic ratio and increased skin conductance. This opposes previous research on other meditative practices, which found a decrease in sympathetic activity (Lu & Kuo, 2003; Motivala et al., 2006) and decreased sympathetic/parasympathetic ratio in meditators (Takahashi et al., 2005). Other qigong research has shown acute decreases in skin conductance (Tang et al., 2009). The observed sympathetic boost may be a peculiarity of FLG and could be related to feelings of increased energy after practicing, though it does not correlate significantly with energy/arousal mood ratings. It is also possible that novices were stressed by the length of the session, which may have contributed to high skin conductance levels.

Neither the "experience" nor the "optimality" hypotheses about acute effects were supported, with no difference between the groups in the amount of change from before to after the FLG session. A lack of baseline differences argues against the optimality hypothesis, but is consistent with the experience hypothesis. These results mean that the pattern of acute effects is still open to investigation, because the current findings suggest that expertise does not influence acute effects. Such a counterintuitive finding would require further evidence, and it may be possible that there was not enough power to detect a difference in acute effects between the groups.

The mood findings agree with reports that qigong and other movement meditation practices acutely improve mood (Johansson et al., 2008; Kimura et al., 2005; Shapiro et al., 2007). This extends previous research, showing that even the initial session of movement meditation can increase energy/arousal moods and reduce negative mood. Ninety minutes, however, appears to have been too long for novices, given that energy moods were rated highest mid-session, after the standing exercises. It is not known if the length itself was the issue, however, or if sitting meditation is particularly difficult for novices, or both.

Practitioners, as expected, showed improvement across all three times for positive and energy moods. Negative moods did not show any change for practitioners, though this may be because of practitioners' initially low ratings. With any self-report questionnaire there is the possibility of bias (e.g., trying to please the experimenter), but the novice reports, with lower scores at the end than the middle for energy/arousal moods, seem unlikely to be a product of bias, and should be seen as an indication that the standing exercises improve mood. Because there is no sham control, however, it cannot be said for certain that these effects are specific to FLG, or to slow-movement exercise in general.

Baseline Differences

Contrary to the hypotheses, no baseline differences were found in any of the physiological measures. This indicates that though the exercises appear to acutely change physiology, these changes may not become chronic differences. It is possible that physiological benefits of the exercises must be maintained by regular practice on a day-to-day basis.

None of the hypotheses concerning baseline psychological differences were borne out. Better overall sleep in practitioners was not found, although a significant difference in sleep latency was discovered, showing that practitioners fall asleep much more quickly than novices. From the reports by practitioners, it appears they may have a reduced need for sleep, but the PSQI was not sensitive to any differences that may exist between the groups. No differences were found for reported numbers of symptoms of illness, which is surprising given reports in the literature about qigong and FLG's benefits for health, specifically Li et al. (2005), which showed FLG practitioners have enhanced immune function.

However, a number of correlations suggest that practitioners who practice the most experience the greatest benefits. Hours practiced per week is associated with decreased anxiety and depression, suggesting that if the sample consisted of practitioners who all practiced more frequently, overall group differences might have been significant. Similarly, amount of time reading the FLG books is associated with better sleep, and years practiced predicts better mood and energy ratings. This suggests that the practice does benefit anxiety, depression, sleep, and mood, but may require frequent, consistent performance of the exercises and study of the FLG texts.

Limitations

The imbalance of gender between the groups may impact the interpretation of the findings, however, the analyses did not find that gender interacted with any of the effects. Ethnicity is also not balanced between the groups, with a predominance of Asians in the practitioner group, and a more varied sample in the novices. There is also an issue of low statistical power because of the sample size, which may have failed to reveal true differences between the groups or acute effects of FLG.

Conclusion

Overall, the results suggest that the FLG exercises do produce acute effects, and can immediately benefit the moods of both practitioners and novices, as well as increase sympathetic activity. Although no baseline differences were found between groups for psychological factors, correlations of practice frequency suggest that dedicated practice of FLG can provide psychological benefits such as improved sleep and mood, and decreased anxiety and depression.

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Paper 2

Cognitive Effects of Falun Gong Qigong

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Abstract

This study examines 1) baseline cognitive differences between 18 experienced Falun Gong (FLG) practitioners and 10 novices and 2) acute cognitive effects after a 91-minute sequence of the FLG qigong exercises. We employed a Lateralized Attention Network Test (LANT) that measures conflict resolution and spatial orienting in each hemisphere. FLG practitioners showed an advantage in accuracy for both interhemispheric and right-hemisphere trials, and the groups showed a difference in sensitivity to implicit spatial emotional cues. Both groups improved in overall reaction time on the attention task after practicing the FLG exercises. In practitioners, changes in high-frequency heart rate variability correlated positively with changes in accuracy in the right hemisphere, but negatively with changes in speed in both hemispheres combined. In the same group, changes in skin conductance correlated positively with changes in accuracy in the right hemisphere, but the changes in skin conductance did not correlate with changes in reaction time. Our results suggest that for practitioners, cognitive improvement from pre- to post-FLG can be attributed to the FLG exercises.

Cognitive Effects of Falun Gong Qigong

Interest in meditation and "movement meditation" (Larkey, Jahnke, Etnier, & Gonzalez, 2009) has grown over the last several years, with yoga alone having more than 15 million practitioners in the United States (Yoga Journal, 2008). Movement meditation encompasses practices such as yoga and qigong, a family of practices with origins in China that is sometimes called "Chinese yoga." These practices involve slow deliberate movements combined with aspects of meditation. Tai Chi is considered a member of this family (Larkey et al., 2009) and enjoys wide popularity, but the most popular qigong practice in China was at one time Falun Gong (FLG). After being introduced to the Chinese public in 1992, FLG grew to an estimated 70–100 million practitioners by 1999 (The Epoch Times, 2004). One reason for its popularity is thought to be reports of remarkable transformations of health that happen after practicing (Dan, 1998; Minghui, 2008; The Epoch Times, 2004). The practice is a good research target for several reasons: the movements are guided by a standard recording with music and instructions specifically created for FLG, always done the same way and for the same amount of time; the movements are relatively simple compared to other practices; and both seated meditation and standing exercises are incorporated in the practice. Thus, although FLG is a qigong practice, it can also be compared to meditation.

FLG has been the subject of little scientific research, with only one journal publication in English (Li, Li, Garcia, Johnson, & Feng, 2005). In China, research related to FLG is discouraged or punished by the government, unless it agrees with the government's persecution and propaganda campaign instituted in 1999, which aims to "eradicate" the practice (The Epoch Times, 2004).

Typically, FLG practitioners perform the exercises while focusing on the practice's music, often outdoors in groups. The movements include gentle stretching, slow movement, and postures that are held for extended periods of time while the eyes are closed. The main idea of the meditative aspect of the practice is that the mind should not be directed toward anything, with the exception of the music, so there is no focus on the breath or any deliberate mental activity, such as reciting a mantra (Li, 2003). In FLG, the exercises are part of a larger spiritual discipline that is based on improving oneself in accord with the principles of truthfulness, compassion, and forbearance (Li, 2000).

Many studies on qigong have focused on purported chronic effects, such as attentional or immune differences in experienced meditators compared with controls. Also of interest, however, are acute effects, that is, the immediate effects attributable to a given practice or intervention. However, acute effects need to be differentiated from acute differences, the observed difference before and after a given intervention that may or may not be attributable to the intervention per se. An acute difference might also include improvements from repeated performance on a task, for example.

Few studies have examined acute cognitive effects after having practiced qigong (e.g., Tang et al., 2007) and there are few published results that examine acute effects using the same tests as those used to evaluate chronic changes. This is true of meditation research in general (cf. Kozhevnikov, Louchakova, Jospiovic, & Motes, 2009). It has been suggested that the results of some investigations of long-term effects of meditation practice may actually be reflecting acute effects. Oftentimes subjects are tested right after practicing qigong or after meditating (Hodgins & Adair, 2010); frequently investigators do not state whether participants meditated the day of the study (e.g., Jha et al., 2007; van den Hurk et al., 2010). Acute effects are important to understand because they should be informative of how chronic changes come to be, giving insight into how cognitive function improves over time through meditative practices. Immediate changes may also reveal how attention and other cognitive factors relate to physiological changes and conditions.

Attention has been the most commonly studied cognitive process affected by meditation, though it is much less so for qigong research. One influential test is the Attention Network Test (ANT), which measures the components of selective attention following Posner's model (Fan, McCandliss, Sommer, Raz, & Posner, 2002). These components include spatial orienting, conflict resolution, and alerting. Using the ANT, it was found that people with qigong or meditation experience are better able to deal with distraction, including both Eriksen flanker-type conflict resolution and spatial reorienting (Jha, Krompinger, & Baime, 2007; Tang et al., 2007; van den Hurk Giommi, Gielen, Speckens, & Barendregt, 2010). Van den Hurk et al. (2010) found that experienced meditators were less affected by invalid orienting cues than matched controls, confirming the prediction that meditators are better at disengaging their attention from such cues. This was not, however, found for qigong in a 5-day intervention study using randomly assigned participants (Tang et al., 2007). On a task with some commonalities with the ANT, Hodgins and Adair (2010) similarly found that experienced meditators exhibited less interference with invalid orienting cues compared to controls. A 10-day meditation intervention was also found to improve working memory performance (Chambers, Lo, & Allen, 2008), as has a 4-day intervention (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010).

Given the right hemisphere's specialization in the orienting of attention (Posner & Petersen, 1990), it has been suggested that hemispheric differences in the brains of meditators favor the right hemisphere. However, most studies on meditation and qigong have not used behavioral tasks that are sensitive to laterality effects (e.g., Jha et al., 2007, Tang et al., 2007, van den Hurk et al., 2010). One behavioral study has shown an acute "right hemisphere shift" in activation following meditation (Meissner & Pirot, 1983), and neuroanatomical data showed increased cortical thickness in the right hemisphere in meditators (Lazar et al., 2005). Additionally, Luders et al. (2012) have shown increased thickness in the border between the first and the second anterior third of the corpus callosum in meditators, which suggests increased connectivity, possibly in the premotor or other frontal areas.

Split-brain research suggests that the cerebral hemispheres are two separate systems that both interact and work alone, and that each hemisphere has its own attention networks for coordinating information processing (Zaidel et al., 2011). This is true for normal subjects as well, since numerous tasks can be shown to be processed in either hemisphere, often with varying degrees of effectiveness. Hemisphericity can be manipulated in normal subjects by controlling presentation of information to the left or right visual field (VF) and controlling the response hand for a task. When target VF (input) and response hand (output) are controlled by the same hemisphere (e.g., left VF-left hand or right VF-right hand) and each hemisphere can perform the task by "itself," there is no need for interhemispheric transfer. By contrast, when the target VF and response hand are controlled by opposite hemispheres (e.g., left VF-right hand or right VF-left hand) then there must be sensory, cognitive, or motor transfer before the response. This interhemispheric transfer usually results in increased reaction time and decreased accuracy (Zaidel, 1983). When interhemispheric transfer is facilitated, the resulting decrement in performance is minimized (Zaidel & Iaocoboni, 2003). The Lateralized Attention Network Test (LANT), developed by Zaidel and associates (Greene et al., 2008), is a variant of the ANT that probes attention in each hemisphere by lateralizing input to one visual field and probes output by restricting responses to one hand.

How the physiological effects of qigong are related to the cognitive changes that come about from practice has not been thoroughly investigated, and it is not known if any particular physiological system plays a selectively important role in cognitive changes from qigong or meditative practices. Previous research, not related to meditation, has shown that increased levels of parasympathetic activity are associated with better attentional and cognitive performance (Hansen, Johnsen, & Thayer, 2003; Suess, Porges, & Plude, 1994). Thus, it is of interest to determine if changes in parasympathetic activity are related to changes in the cognitive measures used in the current study, which differ from those in non-meditation-related physiological studies (mentioned above).

Research Objectives and Design

The purpose of this article is to present data on the acute cognitive effects of practicing the FLG exercises, baseline differences between practitioners and novices, and correlations between physiological and cognitive changes as a result of the exercises. To carry this out, we compared differences between practitioners and novices using a before-and-after design, using both cognitive and psychophysiological measures. This paper focuses on the cognitive results and their relationship to some physiological data.[2]

Experienced FLG practitioners performed the FLG exercises between undergoing physiological measurements and performing a number of cognitive tasks. A comparison group of novices underwent the same assessments and performed the same exercises. Acute differences were compared to determine the effects of a single session of FLG. Baseline differences were also compared at the same time to examine the long-term effects of practicing FLG.

The design has certain limitations. To understand the effects of FLG, an ideal experiment would involve a longitudinal study over a period of years with three randomly assigned groups: a FLG group, a sham FLG group (to control for the effects of slow-movement exercise and other factors that are not exclusive to FLG), and a group to test the repetition effects of the cognitive tasks. (The term "repetition effect" will be used throughout instead of "practice effect" to prevent possible confusion with the effects of practicing FLG.) The differences between the groups over time would allow the assessment of FLG's true effects, as well as the effects of slow-movement exercise in the sham group. As a more feasible alternative, the current design was developed, which

[2] Research conducted for the dissertation requirement for a Ph.D. See Paper 1, Physiological and Psychological Effects of Falun Gong Qigong.

can detect acute effects (i.e., the effect of a single session of FLG), examine baseline differences between the groups, and possibly show interactions between the two. If acute effects are found for the same measures as baseline differences between the groups, it would suggest the baseline differences might be chronic changes due to some aspect of FLG.

Hypotheses

Acute effects. Previous research has largely focused on the difference between practitioners performing the intervention of interest and other subjects undergoing an alternate, control intervention (e.g., Kozhevnikov et al., 2009; Tang et al., 2007). In this study, because both groups are performing the same intervention, it allows the testing of different hypotheses about the acute effects of FLG. According to the "experience" hypothesis, the exercises should have larger acute benefits for practitioners because these participants are better at performing the exercises than novices, but there should be little or no baseline differences. By contrast, the "optimality" hypothesis predicts that while practitioners are better at doing the exercises, they have chronically accrued the benefits of the exercises, and would have less room to change than novices, therefore showing smaller acute effects, but larger differences at baseline. A third hypothesis is that both groups will change equally, as a result of general repetition effects or a combination of repetition and acute effects that affect both groups equally. Thus, an interaction between Group and Pre/post-exercise would suggest an acute effect of FLG and not a mere repetition effect. However, such an interaction might still only reveal an acute difference, because the improvement could be due to factors such as general effects of slow-movement exercise, rather than something specific to FLG. Listed below are hypotheses relating to differences between the groups, which can be applied to all three above hypotheses, unless otherwise noted.

Attention. Because FLG and meditation in general involve overcoming distraction in order to maintain attention, FLG practitioners should

1) show overall increased accuracy and reduced reaction time for choice RT tasks,

2) be able to overcome competing cues and distraction both in space and over time, and

3) maintain more desired information in their working memory.

Laterality. There is rich evidence that spatial orienting is a right hemisphere-specialized process (Posner & Petersen, 1990). More recent anatomical evidence shows that meditators have thicker areas in the right hemisphere (Lazar et al., 2005), and that meditators have thicker areas in the corpus callosum (Luders et al., 2012). Consequently, we expect to find that, compared to novices, practitioners have

1) better right-hemisphere performance in terms of both accuracy and RT, and

2) higher accuracy and shorter reaction time on trials involving interhemispheric transfer.

Motor coordination. Because the exercises involve slow movements that require attention to the body, and constitute a practiced, coordinated skill, it is expected that practitioners will score better on motor coordination than novices.

Effects due to emotional control. As part of FLG, practitioners cultivate themselves by letting go of attachments (Li, 2000), including being overly affected by emotions. As a consequence, practitioners, compared to novices, should be less negatively affected on attentional performance by emotional cues. This will only be expected at baseline, because it is not directly related to the FLG exercises.

Associations of cognitive and physiological effects. Based on findings and theories that increased parasympathetic activity is associated with improved cognitive performance (Duschek, Muckenthaler, Werner, & Reyes del Paso, 2009; Hansen et al., 2003; Suess et al., 1994), it is predicted that higher levels of and greater changes in parasympathetic activity should correspond with better scores and larger improvements in the cognitive tasks.

We will revisit these hypotheses in more specific terms in the Data Analysis section.

Methods

Participants

Table 2.1 lists the demographic details for participants with complete data for both the FLG-practitioner group and the novice group.

FLG practitioners. Twenty-four experienced FLG practitioners were recruited, 18 of whom met the exclusion and data quality criteria (7 male, 11 female; 6 white, 12 Asian). Practitioners' average age was 41.2 years. Practitioners were recruited through contacts of the author and other participants. See Table 2.2 for details on amount of time spent on FLG activities. Practice occurs both alone and in groups. For all participants, exclusions were: must be right handed, no physical limitations that might preclude doing the exercises, no medications that might affect the physiological measures, and no self-reported psychiatric conditions.

Novice group. Twenty-four novices were recruited through advertisements on craigslist.com, newspaper ads, and distribution to UCLA staff mailing lists, 10 of whom qualified based on the exclusion and data quality criteria (5 male, 5 female; 3 white, 4 Asian, 1 Hispanic, 1 African-American, 1 mixed). Novices' average age was 39.5 years. Exclusion criteria for novices were: no prior experience with FLG, a maximum of three recent months with other qigong or meditation practices in the last 5 years, and not currently practicing. Four novices reported having some meditation experience (ranging from 1 to 27 years ago). The recruiting was targeted toward people interested in FLG.

Participants in both groups were compensated $45 and parking was reimbursed. One practitioner did not accept payment.

Table 2.1. Demographic information for participants.

Demographics		Practitioners	Novices
Gender	Male	7	5
	Female	11	5
	Age (years)	41.2 (31–65)	39.5 (27–61)
Ethnicity	White	6	3
	Asian	12	4
	Hispanic	0	1
	African American	0	1
	Mixed	0	1
	Education (years)	17.2 (13–23)	16.1 (14–23)
Work	Professional/technical	9	5
	Blue collar	1	2
	Helper/assistant	1	0
	Student	1	1
	Retired	0	1
	Unemployed/housewife	6	2
	Full time	9	3
	Part time	6	5
	Exercise (hours/week)	6.8 (0–21.75)	10.9 (0–23)
Menstrual status	Regular	8	3
	Post-menopausal	1	1
	Birth control	0	2

Table 2.2. Statistics on amount of time spent on FLG activities

Amount of FLG Practice	Mean	Range
Years practiced	9.9	2–18
Exercise frequency (hours/week)	9.7	1.46–16.5
Time spent reading FLG literature (minutes/day)	71.9	20–150

Procedure

Participants went to the UCLA Psychophysiology Lab on two separate days, within a span of two weeks. The sessions were split across two days in order to avoid fatigue effects, with the assumption that data collected in the first session is a fair substitute for collecting it in the second session. All subjects were run individually, and came at approximately the same time of day for both sessions. Practitioners were asked not to perform the FLG exercises prior to the visit on either day. The first day subjects signed the consent form, filled out questionnaires, and then performed the cognitive tasks. On the second day, subjects filled out a questionnaire, then underwent physiological recordings, then performed the FLG exercises, again had their physiological measures recorded, and finally did the same cognitive tasks as in the first session, in the same order. The LANT was always performed first because it was thought to be the most sensitive to acute effects. Mood questionnaires were administered immediately before, mid-session at the 1-hour point, and immediately after the exercises were performed. After completing the cognitive measures, participants were debriefed, paid, and thanked. See Table 2.3 for order and duration of the different tasks and procedures for both days. Results for the physiological recordings and questionnaires are reported elsewhere.

Table 2.3. Breakdown of the procedure for both days, with time for each step.

Overall Procedure			
Day 1		**Day 2**	
Consent	5 min	Questionnaire	3 min
Questionnaires	25 min	Setup	5 min
Attention task	30 min	Physiological recordings	15 min
Coordination task	5 min	Mood questionnaire #1	2 min
Working memory task	10 min	FLG standing exercises	60 min
		Mood questionnaire #2	2 min
		FLG sitting exercise	31 min
		Mood questionnaire #3	2 min
		Setup	5 min
		Physiological recordings	15 min
		Attention task	30 min
		Coordination task	5 min
		Working memory task	10 min
		Debriefing and payment	5 min
Total:	**75 min**		**190 min**

Practitioners performed 91 minutes of the exercises, and novices performed 76 minutes, plus 15 minutes of instruction when they also carried out some of the movements (see Table 2.4 for details on the exercises and times). The exercises were performed along with the standard FLG music recording of Chinese music with FLG's founder calling out positions and movements in

Mandarin. This allows practitioners to perform the exercises in sync without needing to look at others. The author performed the exercises along with the experienced participants. The author also taught and performed the exercises along with the novices, allowing for a minimum of corrections, which might otherwise disrupt the participants. Participants could observe what the instructor was doing without having to inquire in the case of uncertainty or a lapse of memory.

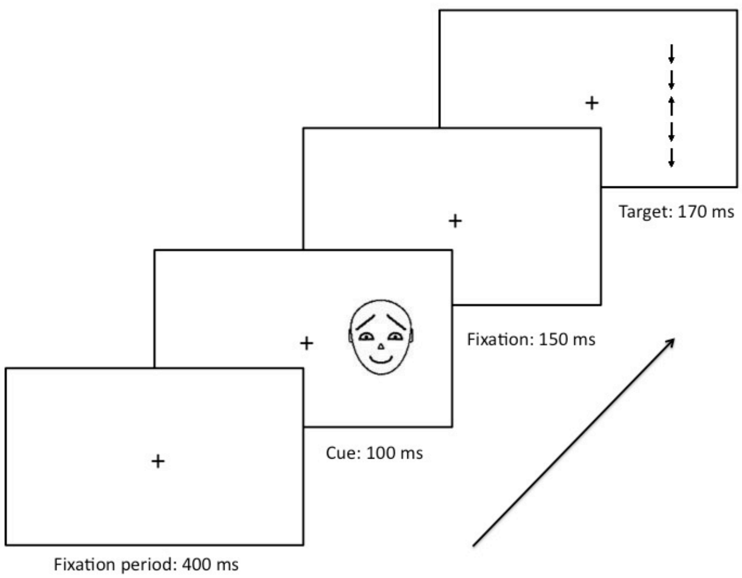
Table 2.4. Breakdown and physical description of the FLG exercises. Complete descriptions and videos of the exercises can be found at www.falundafa.org.

Falun Gong Exercises			
Practitioners		**Novices**	
		Instruction	15 min
Standing exercises	**1 hour**	**Standing exercises**	**45 min**
1st: gentle stretching	10 min	1st: gentle stretching	10 min
2nd: Four "wheel holding" postures	30 min	2nd: Four "wheel holding" postures	15 min
3rd: slow arm movements	8 min	3rd: slow arm movements	8 min
4th: slow movements around the body	12 min	4th: slow movements around the body	12 min
Sitting meditation	**31 min**	**Sitting meditation**	**31 min**
Arm movements	1 min	Arm movements	1 min
Arms held out	5 min	Arms held out	5 min
Arm held below chin	5 min	Arm held below chin	5 min
Other arm below chin	5 min	Other arm below chin	5 min
Hands held in lap	15 min	Hands held in lap	15 min
Total:	91 min		91 min

Assessments and Stimuli

Lateralized Attention Network Test. The Lateralized Attention Network Test (LANT) (Greene et al., 2008) was based on the Attention Network Test (ANT) (Fan et al., 2002). The LANT measures the same three different networks of attention that the ANT does, but can also discriminate hemispheric effects by presenting the targets to the left or right VF and manipulating output by response hand. The original ANT presented cues and targets either directly above or below a central fixation point, thus minimizing hemispheric effects. The version of the LANT used here (Crump, 2012) includes automatic peripheral spatial cues that consist of lateralized cartoon faces with facial affects (happy, angry, neutral). Thus our test incorporates a lateralized Eriksen flanker task, lateralized choice reaction time spatial orienting task, and a test for measuring the implicit effects of emotional cues on target identification.

Figure 2.1. Schematic of the LANT. Cues take the form of one of three faces, and targets are arrows surrounded by four other arrows. This is an example of a valid trial, presented to the right visual field, with an incongruent target. In an invalid trial, the face would have appeared on the left. Stimuli not drawn to scale.



The basic structure involves a central fixation point (.25° of visual angle in width and height) and a target that appears 2° to the left or right of the fixation point on the horizontal meridian. The target is the middle arrow (.6° of visual angle) of five vertically arranged arrows (total height 3° of visual angle, .5° width) and the task is to indicate whether the arrow is pointing up or down. Subjects are instructed to respond according to the direction of the middle arrow by pressing the buttons on a computer mouse held on its side. The top button is pressed by the index finger for up arrows, the bottom button is pressed by the middle finger for down arrows. On two of the four blocks the buttons are pressed with the left hand, the other two with the right.

To manipulate conflict, the middle arrow is flanked above and below by two pairs of arrows that always point in the same direction as each other, either up or down. On half of the trials, the flankers are pointing in the same direction as the middle arrow (congruent), and for the other half the flanking arrows are pointed in the opposite direction (incongruent) (see Figure 2.1).

For the purposes of manipulating the orienting of attention, the arrows are preceded by a spatial cue, consisting of a cartoon face (measuring 1° by .75° of visual angle), which always appears 250 ms before the target. The cue can appear in the center of the screen, replacing the fixation cross, or centered 2° to the left or right of the fixation cross at the two possible locations of the target. Cues appearing to the left or right are valid 75 percent of the time, and invalid 25 percent of the time, so that participants are more likely to treat the cue as predictive. The cues are cartoon faces representing three emotions: happy, neutral, and angry, based on Ohman, Lundqvist, and Esteves (2001) (see Figure 2.2). The use of emotional cues is a variation of Greene et al. (2008) and is intended to detect differences in the processing of emotions between the groups (Crump, 2012).

Figure 2.2. Emotional faces used as cues for the LANT (from Ohman, Lundqvist, and Esteves, 2001).

For each trial, a fixation cross appears for 400 ms, followed by a face cue for 100 ms, followed by another fixation for 150 ms before the target is shown for 170 ms. Participants have 1 second to respond, or the trial is considered incorrect. This version of the LANT is also faster than the one used by Greene et al. (2008), with less time between cue and target, and less time after the target is responded to.

By comparing the accuracy or reaction time (RT) between different types of trials, one can calculate the Orienting Benefit (difference between targets following center and valid cues), Orienting Cost (difference between targets following center and invalid cues), and Conflict (difference between congruent and incongruent targets).

Participants are instructed to fixate on the center of the screen throughout the trial and to respond as quickly and as accurately as possible. Everyone was given at least 19 practice trials with feedback. Those who did not perform up to criterion were given extra practice trials to help ensure that they could perform the task up to 60% correct. The actual trials provided no feedback. Each block consisted of 54 trials.

Motor coordination. Motor coordination was assessed with a pursuit rotor task from the suite of experiments in PEBL (Psychology Experiment Building Language, Mueller, 2010). Subjects use the mouse on a computer to keep the cursor within a moving target as accurately as possible, and time spent within the target is measured in milliseconds. The target is a red circle about 1 inch in diameter, which itself moves in a circular pattern, completing a circuit every 7.5 seconds. Participants completed a total of 8 trials of 2 circuits each. The target changes color when the cursor is successfully inside of it, giving participants feedback about their performance. Participants were given no practice trials.

Working memory. Working memory was assessed using a measure called the computation span (CSPAN) that assesses working memory by having participants store numbers in their memory while simultaneously performing simple addition and subtraction. Participants must first memorize three strings of 4 numbers, then three strings of 5 numbers, and so on up to 8 at a time. The total possible score is 90. All numbers and equations are presented in numerals on the computer. This task was chosen to avoid bias against non-native English speakers, and is based on Conway et al. (2002). Participants received one practice trial of 4 items to familiarize themselves with the procedure.

Physiological measures. Heart rate, heart rate variability (HRV), and skin conductance were measured.[3] Heart rate variability (HRV) examines low frequency (LF) power and high frequency (HF) power components using the serial interbeat intervals from the heart rate. LF-HRV and HF-HRF are reported in both ms^2 and normalized units. From these normalized units, the ratio of LF over HF was also calculated. The HF spectrum is considered a measure of parasympathetic activity (Akselrod et al., 1981) and LF spectrum a combination of both sympathetic and parasympathetic activity (Appel, Berger, Saul, Smith, & Cohen, 1989). LF/HF-HRV is a measure of sympathetic/parasympathetic balance, with higher values indicating greater sympathetic activity (Task Force, 1996). Skin conductance is a measure of sympathetic activity.

Data Analysis

All of the cognitive tasks (LANT, CSPAN, and the Pursuit Rotor Task) were analyzed using ANOVA, using Group as a between-subjects factor and Pre/post-exercise as a within-subjects factor. For the LANT, Gender was used as a covariate. Because there is a gender imbalance between the groups, Gender was added as a factor for the analysis. When it is added as a factor for the LANT, there are several interactions with other factors (Cue, Congruity, and Emotion), and consequently Gender was used as a covariate in the final analysis. For the CSPAN and Pursuit Rotor Task, however, there were no interactions with Gender, so it was not included in the final analysis.

The LANT was analyzed using three additional factors: cue position (Cue: valid, center, invalid), congruity of target flankers (Congruity: congruent, incongruent), and emotion of cue (Emotion: happy, neutral, angry). Furthermore, the data were split into two complementary partitions: "hemisphere-pure," which involves only trials where the hemisphere of the response hand matches the hemisphere of visual presentation of the target, and "cross-hemisphere," where the hemisphere of the response hand does not match the hemisphere of visual presentation of the

[3] For more information the on physiological measures, see the other part of the dissertation, Physiological and Psychological Effects of Falun Gong Qigong.

target. These partitions used a total of six factors: the same as the overall analysis, as well as Hemisphere (left VF-left hand, right VF-right hand) and VF/Response Hand Cross (left VF-right hand, right VF-left hand), for hemisphere-pure and cross-hemisphere, respectively. Furthermore, analyses were performed for individual cues: valid, center, and invalid, which included all the other factors except Cue. Valid cues were also analyzed separately for the hemisphere-pure and cross-hemisphere partitions. Lastly, Orienting Benefit (valid cues minus center cues) and Orienting Cost (center cues minus invalid cues) accuracy and RT were used as dependent variables in additional analyses. ANOVA was used instead of t-tests to follow up interactions in order to maintain use of the covariate of Gender; univariate ANOVA was used to test between-groups comparisons, and repeated measures ANOVA for within-groups comparisons. All analyses were done both for accuracy and reaction time. The coordination task was analyzed using time-on-target as the dependent variable, and Working Memory used total score as the dependent variable.

Relations between the physiological and cognitive measures were examined by correlating scores or changes in scores for cognitive measures to levels and changes in physiological measures. These comparisons were made using Pearson's r. The analyses were done separately for each group.

Predictions

Following are more specific predictions based on the previous hypotheses. The "experience" and "optimality" hypotheses for acute effects apply to all below. Hypotheses that did not need further explanation are not described.

Attention. 1) *Practitioner advantage*. Practitioners should show greater accuracy overall and lower reaction time on the LANT than novices (main effect of Group for both accuracy and RT), and 2) *Distraction hypothesis*. On the LANT, practitioners should show a smaller difference between valid and central cues than novices (van den Hurk et al., 2010) (main effect of Group, Orienting Benefit as the dependent variable), as well as between center and invalid cues than novices (main effect of Group, Orienting Cost as the dependent variable), and be better than novices at center and invalid cues in general (main effect of Group for center cues and main effect of Group for invalid cues). Practitioners should show less conflict than novices on accuracy and RT (interaction of Group x Congruity).

Laterality. 1) *Right hemisphere benefit.* Because meditation is thought to be a right-hemisphere process (Lazar et al., 2005; Ornstein, 1972; Posner & Petersen, 1990) on trials involving information presented to the left visual field and responses by the left hand (ipsilateral), practitioners should be faster and more accurate, and show a greater difference between the left and right hemispheres, than novices (interaction of Group x Hemisphere). This should be particularly so for trials with valid cues, where cue, target, and response hand are all in the same hemisphere. 2) *Interhemispheric benefit.* Based on Luders et al. (2012), we predict that practitioners should show greater accuracy and faster reaction time than novices for valid trials involving crossing visual field and response hand (i.e., left visual field and right response hand, and vice-versa). By restricting the comparison to valid trials, the crossing of visual field and response hand should be the only interhemispheric process involved (main effect of Group for cross-hemisphere partition valid cues only).

Emotional control. *Reduced negative effects.* Practitioners should show fewer negative effects from happy and angry cues, compared to neutral ones, particularly in difficult conditions, which have higher cognitive load, such as invalid cues when the target is incongruent (interaction of Group x Congruity x Emotion).

Association of cognitive and physiological effects. HF-HRV scores should correlate positively with accuracy and negatively with RT on the LANT, and changes in HRV should correlate positively with changes in accuracy and negatively with changes in RT on the LANT.

Results

For the present analysis, alpha equal to .05 is considered significant.

Cognitive Measures

Pursuit Rotor Task. No significant differences were found between the groups for time on target (ms per trial) at baseline (t (26) = .751, p = .46), but there was an overall effect of Pre/post-exercise (F (1,26) = 22.93, p < .001), with both groups improving. See Table 2.5 for details.

Computational Span. One novice did not complete the post-FLG CSPAN owing to time limitations. There were no significant differences for Group at baseline (t (1,26) = .24, p = .82) for Pre/post-exercise (F (1,25) = .78, p = .39) or Group x Pre/post-exercise (F (1,35) = .157, p = .69). See Table 2.5 for details.

Table 2.5. Results for coordination and working memory tasks.

		Coordination		Working memory	
		Mean (ms)	SD	Mean (items)	SD
Practitioners	Pre	9453	1690	60.67	20.95
	Post	10507	1563	63.00	23.21
Novices	Pre	10011	2201	57.00	18.38
	Post	10678	1770	60.00	12.94
Group (baseline)		*n.s.*		*n.s.*	
Pre/post		*< .001*		*n.s.*	
Group x Pre/post		*n.s.*		*n.s.*	

Lateralized Attention Network Test. If participants did not reach a criterion of at least 60% accuracy each session, they were excluded from the study (3 out of 24 practitioners; 11 out of 24 novices). Additionally, if participants responded to the flankers instead of the central cue, they were excluded (1 practitioner, 1 novice).

Acute effects. No clear support was shown for either the "experience" or "optimality" acute effect hypotheses. The two-way Group x Pre/post-exercise effects were not significant for accuracy or reaction time, nor were other predicted acute effects having to do with cue, laterality, or emotion. There was a main effect for Pre/post-exercise for both groups of reaction time (F (1,26) = 5.41, p = .028), but not for accuracy (F (1,25) = 1.68, p = .21). See Table 2.6 for details.

Baseline differences. This section will be organized by hypotheses.

Attention hypothesis 1: Practitioner advantage. The hypothesis that practitioners would be more accurate and faster than novices (main effect of Group) was not confirmed for either accuracy (F (1,25) = 1.67, p = .21) or reaction time (F (1,25) = .25, p = .62). See Table 2.6 for details.

Table 2.6. Overall accuracy and reaction time for both groups. Values are adjusted for gender covariate.

		Overall accuracy		RT	
		Mean (%)	SD	Mean (ms)	SD
Practitioners	Pre	0.75	0.07	506.72	15.27
	Post	0.81	0.08	483.10	15.75
Novices	Pre	0.72	0.10	493.86	20.52
	Post	0.77	0.11	465.80	21.16
Group (baseline)		n.s.		n.s.	
Pre/post		n.s.		0.028	
Group x Pre/post		n.s.		n.s.	

Attention hypothesis 2: Distraction hypothesis. Practitioners were predicted to be superior in overcoming distraction in the form of targets with incongruent flankers (Group x Congruity). This hypothesis was not supported for accuracy (F (1,25) = .72, p = .40) or RT (F (1,25) = 1.90, p = .18). The hypothesis that practitioners would be less negatively affected by center and invalid cues was also not supported. There were no significant group differences found for Orienting Benefit (difference between valid and central cues, used as dependent variable) (main effect of Group) for accuracy (F (1,25) = .083, p = .78) or for RT (F (1,25) = 1.3, p = .27). See Table 2.7a for details. No significant group differences were found for Orienting Cost (difference between central and invalid cues, used as dependent variable) (F (1,25) = 2.32, p = .14) or for RT (F (1,25) = .05, p = .82). See Table 2.7b for details. There were no group differences for center cues (main effect of Group, center cues only) on accuracy (F (1,25) = .32, p = .58) or RT (F (1,25) = .30, p = .59), or for invalid cues (main effect of Group, center cues only) on accuracy (F (1,25) = 3.39, p = .078) or RT (F (1,25) = .47, p = .50). See Table 2.7c for details.

Table 2.7a. Means and standard deviations for Conflict (difference between congruent and incongruent flankers). Values are adjusted for gender covariate.

		Congruity (ACC)		Congruity (RT)	
		Mean (%)	SD	Mean (ms)	SD
Practitioners	Pre	0.26	0.13	64.46	35.12
	Post	0.21	0.13	65.65	33.22
Novices	Pre	0.29	0.17	52.33	47.19
	Post	0.24	0.18	50.43	44.65
Group (baseline)		*n.s.*		*n.s.*	
Pre/post		*n.s.*		*n.s.*	
Group x Pre/post		*n.s.*		*n.s.*	

Table 2.7b. Means and standard deviations for Orienting Benefit (difference between valid and center cues) and Orienting Cost (difference between center and invalid cues). Values are adjusted for gender covariate.

		Orienting Benefit (ACC)		Orienting Benefit (RT)		Orienting Cost (ACC)		Orienting Cost (RT)	
		Mean (%)	SD	Mean (ms)	SD	Mean (%)	SD	Mean (ms)	SD
Practitioners	Pre	0.062	0.08	38.22	24.53	0.045	0.09	28.53	31.25
	Post	0.054	0.07	33.55	30.36	0.098	0.07	26.47	26.72
Novices	Pre	0.069	0.10	29.34	32.97	0.088	0.12	26.30	41.99
	Post	0.070	0.09	31.91	40.80	0.1	0.10	20.54	35.91
Group (baseline)		*n.s.*		*n.s.*		*n.s.*		*n.s.*	
Pre/post		*n.s.*		*n.s.*		*n.s.*		*n.s.*	
Group x Pre/post		*n.s.*		*n.s.*		*n.s.*		*n.s.*	

Table 2.7c. Means and standard deviations for center and invalid cues. Values are adjusted for gender covariate.

		Center cues (ACC)		Center cues (RT)		Invalid cues (ACC)		Invalid cues (RT)	
		Mean (%)	SD	Mean (ms)	SD	Mean (%)	SD	Mean (ms)	SD
Practitioners	Pre	0.74	0.10	509.95	86.57	0.70	0.10	538.48	79.86
	Post	0.83	0.096	485.46	84.43	0.73	0.12	511.93	83.51
Novices	Pre	0.73	0.13	494.88	116.35	0.64	0.14	521.17	107.32
	Post	0.78	0.13	469.59	113.46	0.68	0.16	490.13	112.23
Group (baseline)		*n.s.*		*n.s.*		*n.s.*		*n.s.*	
Pre/post		*n.s.*		*n.s.*		*n.s.*		*n.s.*	
Group x Pre/post		*n.s.*		*n.s.*		*n.s.*		*n.s.*	

Laterality hypothesis 1: Right hemisphere benefit. A benefit for right hemisphere accuracy was found in practitioners for valid cues for hemisphere-pure trials, with an interaction between Group and Hemisphere ($F(1,25) = 4.37$, $p = .047$) (see Figure 2.3). An analysis of simple effects showed that right hemisphere performance was more accurate in practitioners than in novices ($F(1,25) =$

5.41, p = .028), but there was no difference between groups for left hemisphere performance (F (1,25) = 1.11, p = .302). Within groups, however, no differences were found between hemispheres, for either practitioners (F (1,16) = .13, p = .72) or novices (F (1,8) = .09, p = .77). Valid cues in the hemisphere-pure condition are the only trials where there is no interhemispheric transfer necessary for the response. See Table 2.8 for details.

Figure 2.3. Interaction between Group and Hemisphere, for valid cues where response hand and visual field are in the same cerebral hemisphere ("hemisphere-pure") (p = .047). Practitioners show a right hemisphere advantage that novices do not.

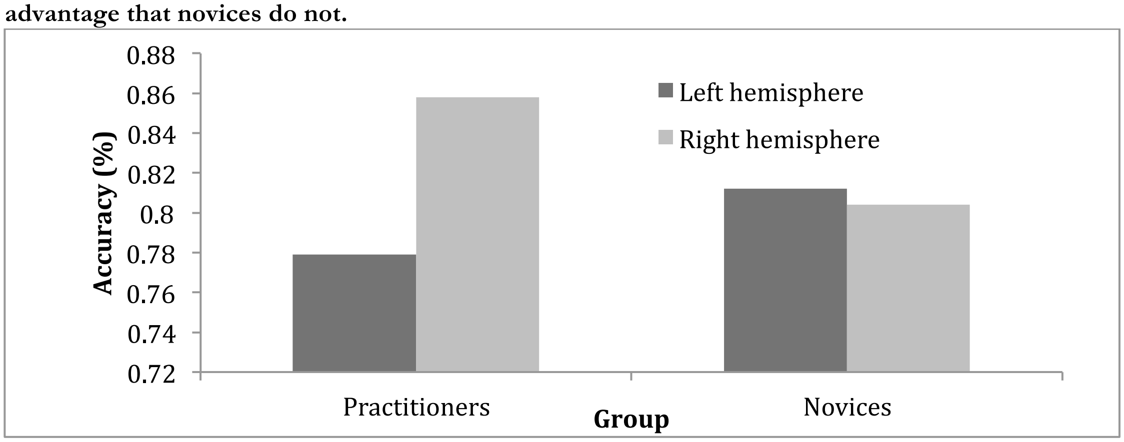


Table 2.8. Means and standard deviation for hemisphere-pure valid cues, by hemisphere. Values are adjusted for gender covariate.

		Accuracy		RT	
		Mean (%)	SD	Mean (ms)	SD
Practitioners	Left hemisphere	0.78	0.10	474.44	92.37
	Right hemisphere	0.86	0.07	465.95	81.39
Novices	Left hemisphere	0.81	0.13	467.21	124.13
	Right hemisphere	0.80	0.10	460.03	109.38
Group (baseline)		*n.s.*		*n.s.*	
Right hemisphere		*0.028*		*n.s.*	
Left hemisphere		*n.s.*		*n.s.*	
Group x Hemisphere		*0.047*		*n.s.*	

Laterality hypothesis 2: Interhemispheric benefit. The prediction that practitioners would show improved interhemispheric transfer for valid cues in the cross-hemispheres partition was not supported for accuracy (F (1,25) = 1.97, p = .17) or RT (F (1,25) = .027, p = .87). However, practitioners had better accuracy for all cross-hemisphere trials when sessions were combined (F (1,25) = 4.61, p = .042).

Emotional control hypothesis: Reduced negative effects. Emotional cues were hypothesized to have less of a negative effect on practitioners, particularly on difficult trials that demand greater resources. This would have most likely produced an interaction between Group x Congruity x Emotion for invalid cues. This interaction was not significant for accuracy ($F(2,50) = 1.25$, $p = .29$). An interaction between Group, Emotion, and Congruity was found for valid cues for accuracy ($F(2,50) = 9.13$, $p < .001$) (see Figure 2.4), showing that novices benefited from emotion. No differences were found within groups for the different emotions, but trials with neutral cues (Group x Cue (valid) x Emotion (neutral)) differed between novices and practitioners ($F(1,25) = 4.56$, $p = .043$), whereas happy cues (Group x Cue (valid) x Emotion (happy)) did not differ ($F(1,25) = .008$, $p = .93$), nor did angry cues (Group x Cue (valid) x Emotion (angry)) ($F(1,25) = .75$, $p = .40$). See Table 2.9 for details.

Figure 2.4. Interaction of Group x Congruity x Emotion for accuracy on valid cues, pre-FLG (p < .001). Conflict (accuracy for congruent targets minus accuracy for incongruent targets) is the dependent variable. Novices do better on cues with emotion than neutral cues, while practitioners are less influenced by emotion. A similar pattern is found for the hemisphere-pure partition. Line graph used here for purposes of illustration, not to suggest these are continuous variables.

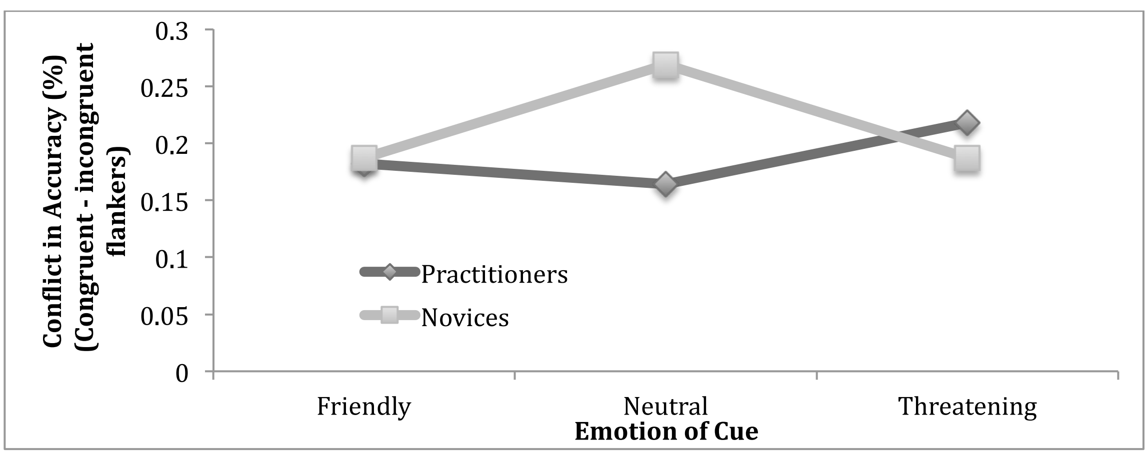


Table 2.9. Means and standard deviations for accuracy for valid cues by Emotion and Group. Values are given in Conflict (congruent minus incongruent flankers) for accuracy. Values adjusted for gender covariate.

	Practitioners		Novices		
	Mean (% conflict)	SD	Mean (% conflict)	SD	Group differences
Happy	0.18	0.16	0.19	0.21	*n.s.*
Neutral	0.16	0.16	0.27	0.21	*0.043*
Angry	0.22	0.11	0.19	0.15	*n.s.*

Association of Cognitive and Physiological Effects

Correlations were assessed for participants who had physiological data available from the other portion of the study. Skin conductance values were available for 14 practitioners (8 females and 6 males) and 7 novices (3 females and 4 males). Heart rate variability data was available for 17 practitioners (11 females and 6 males) and 9 novices (4 females and 5 males).

Of the predicted correlations of HF-HRV and HF-HRV (n.u.) with cognitive performance, increases in HF-HRV (n.u.) were associated with increases in accuracy in the right hemisphere on the LANT for practitioners ($r = .66$, $p = .004$), but an increase in HF-HRV (n.u.) was also associated with an *increase* in RT in both hemispheres ($r = -.73$, $p = .001$). Neither of these associations was present in novices (accuracy: $r = .45$, $p = .19$; RT: $r = .16$, $p = .65$).

For practitioners, increase in SC from pre to post-exercise correlated with an increase in accuracy for the left visual field ($r = .75$, $p = .002$) and right hemisphere pure trials ($r = .68$, $p = .002$). For novices, these correlations were not significant for left visual field ($r = -.12$, $p = .78$) or right hemisphere ($r = -.16$, $p = .70$). In practitioners, higher levels of pre-FLG SC were associated with lower overall pre-FLG RT (considering both hemispheres together) ($r = -.54$, $p = .038$), and post-FLG SC is more highly correlated with post-FLG RT ($r = -.63$, $p = .012$). Novices, however, do not show such a relationship pre-FLG ($r = .17$, $p = .57$) or post-FLG ($r = .27$, $p = .43$).

Discussion

The results presented here demonstrate that Falun Gong (FLG) practitioners show hemispheric differences from novices, and that the FLG qigong exercises have acute effects on psychophysiological relationships. Practitioners show a right hemisphere advantage for accuracy that novices do not, and also show relationships between cognitive performance in the right hemisphere and both sympathetic and parasympathetic activity. Practitioners are also more accurate than novices on trials that involve interhemispheric transfer. Furthermore, acute changes in physiology correlate with acute increases in accuracy for practitioners following the exercises.

Some alternative explanations need to be considered as to whether improvements in the cognitive tasks can be attributed to the effects of the FLG exercises. The difference in performance on the cognitive tasks before and after FLG could be due to an acute effect of FLG, or of slow-movement exercise in general, or to repetition effects. Change in physiological state, however, cannot be due to repetition effects, and therefore it must be an acute effect of FLG or of slow-movement exercise. A correlation of acute physiological effects with cognitive changes would suggest that the cognitive effects are likely due to FLG or slow-movement exercise, and not other reasons such as self-selection effects. Because both the practitioner group and novice group underwent the same procedure, the design eliminates factors such as diurnal rhythms as a cause of differences between the groups.

Cognitive Effects

Acute effects. No straightforward acute effects that differed between the groups were found for the cognitive tasks. Thus, neither the "experience" hypothesis nor the "optimality" hypothesis was supported.

Though no differences in improvement between the groups were found for accuracy or reaction time on the attention task, scores did go up for accuracy and down for reaction time from pre- to post-exercise, with reaction time improving significantly for both groups. To determine if the changes in accuracy or reaction time are repetition effects benefiting both groups equally, or at least partly an acute effect of the FLG session, we examined whether acute changes in physiological measures, which should not show repetition effects, correlated with the change from pre- to post-exercise in either accuracy or reaction time. For practitioners, the increase of parasympathetic activity from pre- to post-exercise correlated with the increase from pre- to post-exercise in accuracy for the right hemisphere (left VF-left hand only), and the increase in skin conductance was correlated with increases in accuracy in the left visual field and right hemisphere (left VF-left hand only). These correlations suggest that improvements in accuracy for practitioners could involve acute FLG effects, and are not entirely repetition effects. The main effect for Pre/post-exercise on accuracy was not significant, though both groups averaged higher post-FLG, and thus there may be a lack of statistical power. Improvements in reaction time did not correlate with changes in physiological measures, suggesting that these are not acute benefits of the practice and are instead probably repetition effects.

Another possible way of disentangling repetition effects from acute effects would be to introduce a third group. Though such a group was not included in this study, we were able to compare the results of the FLG practitioners to a sham biofeedback condition of another study in the Zaidel lab that used a similar version of the LANT (Hill, Lightstone, Fernandes, & Zaidel, in prep). We found an acute effect for accuracy, with practitioners improving more across sessions than the sham group, but no baseline differences were found (no gender covariate was used in this analysis). This effect was not present, however, when comparing novices to the sham group, or when practitioners and novices were compared. Though the comparisons are not ideal because the data come from a different study, they suggest that both practitioners and novices showed acute effects for accuracy, and that practitioners (but not novices) showed an effect that can be distinguished from repetition effects alone. If true, this would also be more consistent with the experience hypothesis for acute effects. Further studies could incorporate a sham or other control procedure to better assess repetition effects.

Both groups improved on coordination, but there are no corresponding physiological correlates; therefore FLG's acute effects cannot be separated from repetition effects. Working memory did not change significant from pre- to post-exercise, and neither were any physiological correlates found.

Baseline differences. No baseline differences were found for the coordination task, suggesting that if the practice does produce any benefits to coordination, they are only acute. An expected baseline difference was not found for working memory in practitioners, putting it at odds with previous meditation research (Chambers et al., 2008; Zeidan et al., 2010). The specific measures used in previous research differed, however, and it may be that the working memory task in this study was less sensitive than in other studies.

It was hypothesized that FLG practitioners would show an overall superiority in accuracy and reaction time on the attention task, because they have trained their attention over years of practice. Neither hypothesis was supported. Previous research by van den Hurk et al. (2010) found that meditation practitioners were more accurate than controls, and this trend was present in the current study, so it may be that the study lacked sufficient power to show this difference in accuracy.

The second attention hypothesis, that practitioners would show fewer negative effects of distraction, was also not borne out. One measure of distraction was Conflict, the difference in performance for targets with congruent and incongruent flankers. Contrary to expectations, practitioners did not show reduced Conflict for accuracy or reaction time. This does not follow previous research (e.g., Jha et al., 2007; Tang et al., 2007; van den Hurk et al., 2010), however, this version of the LANT differs from the ANT used in other research: the targets are lateralized and vertically oriented, and are also presented much more quickly. These differences may make it more difficult for the effects of qigong to be detected, but answering this requires further research. One possibility is that FLG may improve cognitive performance, but not via increased speed of processing.

Practitioners were also predicted to show less of a difference between valid and center cues (Orienting Benefit) than novices, suggesting that practitioners are less distracted by central cues (van den Hurk et al., 2010). This was not found in either accuracy or reaction time, going against findings by van den Hurk et al. (2010), though their version of the ANT had several differences: it was not lateralized and used no invalid cues, thus valid cues were 100 percent predictive of target position. However, Tang et al. (2007), in a study on a qigong-like practice, and using the same version of the ANT as van den Hurk et al., failed to show the orienting benefit effect. The effect thus may be more readily observed in meditators than qigong practitioners. Additionally, no difference was found between central and invalid cues (Orienting Cost) between the groups, which should measure a more extreme disengagement of attention.

Practitioners were not better at invalid cues, as predicted and as found in a similar test by Hodgins and Adair (2010), and also did not show any differences on center cues alone. This lack of difference with center cues fits with the absence of the orienting benefit found in van den Hurk et al. (2010), and with the lack of support for the distraction hypothesis overall. The group difference on invalid cues was close to significance, however, so like overall accuracy, it may be an issue of statistical power.

It was hypothesized that practitioners would be less negatively influenced by emotional cues in difficult conditions than novices, but this was not confirmed. When cues were valid, novices actually showed a benefit for emotional cues, relative to neutral cues, which practitioners did not. This suggests that novices' attention is more drawn by emotional cues, which serves to benefit their performance for valid trials, whereas practitioners are less influenced by emotions than novices. The same phenomenon would be expected to harm invalid trials for novices, but the effect was not found, possibly due to low statistical power.

The prediction that practitioners would have better right hemisphere performance was supported by a difference between groups for right-hemisphere accuracy for hemisphere-pure valid trials. This subset of trials involves the purest lateralized processing, because cue, target, and response hand are all being processed in the same hemisphere. Meditation has been linked to the right hemisphere because orienting of attention is thought to be located in the right hemisphere (Posner & Petersen, 1990) and neuroimaging data has also supported meditators having differences in the right hemisphere compared to controls (Lazar et al., 2005). This present finding is consistent as a behavioral corollary of the reported neuroanatomical differences.

Practitioners were not more accurate than novices for cross-hemisphere valid trials, as hypothesized based on neuroimaging data showing that meditators have thicker fibers connecting the hemispheres (Luders et al., 2012). However, when both the pre- and post-FLG sessions are combined for cross-hemisphere trials, practitioners were more accurate. Thus, the apparent enhanced connectivity may not be limited to motor transfer, but includes more general information transfer, consistent with the possibility that the areas in the corpus callosum where differences were found in meditators were more frontal than motor. This may be a power issue, as well, because the effect is only seen when all cross-hemisphere trials are taken into consideration.

Relation between acute and chronic effects. The question of whether previous results in the meditation literature mainly reflect acute or chronic effects (e.g., Jha et al., 2007; van den Hurk et al., 2010) cannot be completely answered by these data, but the lack of acute effects for differences observed in other studies suggest that previous research has been demonstrating chronic and not acute differences. It was expected that the same effects seen at baseline would also be seen acutely, which would support the idea that baseline differences are resulting from chronic changes from practicing FLG. Given this was not found, the cause of baseline differences found in this study remains to be determined. If these differences do result from chronic changes, then it appears that acute effects are relatively small in magnitude and slowly accrue, eventually being statistically detectable as chronic effects, rather than showing immediate large benefits.

Association of Cognitive and Physiological Effects

The predicted relationship between parasympathetic activity and cognitive performance based on previous studies (Hansen et al., 2003; Suess et al., 1994) was supported by increased levels of parasympathetic activity correlating with increased accuracy in the right hemisphere of practitioners. This same relationship was not found in novices. Practitioners also showed relationships between skin conductance and both accuracy and reaction time not seen in novices.

Particularly intriguing for practitioners is the involvement of the right hemisphere. An acute increase in parasympathetic activity, as seen by increased high-frequency heart rate variability, is associated with an acute increase in accuracy in the right hemisphere, but an acute increase in skin conductance, a measure of sympathetic activity, is also associated with an acute increase in accuracy in the right hemisphere. Thus, increases in both sympathetic and parasympathetic measures are associated with improved performance in the right hemisphere. The right hemisphere has been shown to be more involved than the left hemisphere with both skin conductance (Heilman, Schwartz, & Watson, 1978) and cardiovascular activity (Walker & Sandman, 1982) and with both sympathetic and parasympathetic activity (Spence, Shapiro, & Zaidel, 1996). This, combined with practitioners' better right hemisphere performance, suggests a psychophysiological relationship that may be important for explaining the chronic effects of FLG and qigong in general.

Reaction time, however, tells a different story. Increased parasympathetic activity is associated with increased reaction time in both hemispheres combined, so it is not enhancing performance unilaterally. Higher levels of skin conductance, however, are associated with lower reaction time in both hemispheres combined in practitioners. Further consideration of these relationships is warranted. Because of lost data for novices, there may have been insufficient power to detect relationships between either accuracy or reaction time that were found in practitioners.

Limitations

There are a number of limitations with the data that may interfere with its interpretation. The different male/female ratios in the groups may impact the findings. This was dealt with by introducing gender as a covariate for the LANT analysis because when gender was included as a factor it produced interactions with other factors. Ethnicity is also not balanced, with the novices being much more diverse, and underrepresenting Asians.

A large amount of data was lost for the attention task, in which over half of novices were excluded because of poor performance. Once it was seen that several participants were not making criteria, the experimenter showed participants what the targets looked like before they started the practice trials, and gave additional practice trials to try to ensure better performance. Even so, three practitioners who received the extra practice did not qualify; the same was true for one novice. However, most novices did not receive the extra practice, so this does introduce a confound. More piloting should have been conducted with older participants, who have more trouble with the LANT than younger participants. The lost data and overall low number of subjects also presents a problem of statistical power. A number of marginal effects suggest this may be the case.

Further research should include a questionnaire on laterality, which could have been used to make comparisons with behavioral hemispheric results.

Conclusion

Overall, the results suggest that the FLG exercises produce acute effects, and long-term practice may lead to hemispheric changes. Correlations of changes in physiological data and accuracy were used demonstrate a possible acute cognitive effect for accuracy in the absence of a significantly different change between before and after practicing the FLG exercises. Practitioners have an interhemispheric and right hemisphere advantage for accuracy, and show right hemisphere relationships to both the sympathetic and parasympathetic nervous systems that are not present in novices. How the groups process emotional cues relative to a neutral cue also differs.

Furthermore, the results clarify a question in the literature as to whether previous studies have been reflecting acute or chronic differences, and support the view that chronic differences have been responsible for previously published results. However, further study is required to determine whether all group differences are a result of long-term practice, particularly in the absence of acute effects. Furthermore, further research will be required to disentangle repetition effects from acute effects.

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