THE ACCURACY AND PRECISION OF KINESIOLOGY-STYLE MANUAL MUSCLE TESTING:

DESIGNING AND IMPLEMENTING A SERIES OF DIAGNOSTIC TEST ACCURACY STUDIES

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ABSTRACT

Introduction: Kinesiology-style manual muscle testing (kMMT) is a non-invasive assessment method used by various types of practitioners to detect a wide range of target conditions. It is distinctly different from the muscle testing performed in orthopaedic/neurological settings and from Applied Kinesiology. Despite being estimated to be used by over 1 million people worldwide, the usefulness of kMMT has not yet been established. The aim of this thesis was to assess the validity of kMMT by examining its accuracy and precision.

Methods: A series of 5 diagnostic test accuracy studies were undertaken. In the first study, the index test was kMMT, and the target condition was ***deceit*** in verbal statements spoken by Test Patients (TPs). The comparator reference standard was a true gold standard: the actual verity of the spoken statement. The outcomes of the muscle tests were interpreted consistently: a weak result indicated a Lie and a strong result indicated a Truth. A secondary index test was included as a comparator: Intuition, where Practitioners used intuition (without using kMMT) to ascertain if a Lie or Truth was spoken. Forty-eight Practitioners were recruited and paired with 48 unique kMMT-naïve TPs. Each Pair performed 60 kMMTs broken up into 6 blocks of 10, which alternated with blocks of 10 Intuitions. For each Pair, an overall percent correct was calculated for both kMMT and Intuition, and their means were compared. Also calculated for both tests were sensitivity, specificity, positive predictive value and negative predictive value.

The second study was a replication of the first, using a sample size of 20 Pairs and a less complex procedure. In the third study, grip strength dynamometry replaced kMMT as the primary index test. In the fourth study, the reproducibility and repeatability of kMMT

were examined. In the final study, TPs were presented with emotionally-arousing stimuli in addition to the affect-neutral stimuli used in previous studies, to assess if stimuli valence impacted kMMT accuracy.

Results: Throughout this series of studies, mean kMMT accuracies (95% Confidence Intervals; CIs) ranged from 0.594 (0.541 – 0.647) to 0.659 (0.623 - 0.695) and mean Intuition accuracies, from 0.481 (0.456 - 0.506) to 0.526 (0.488 - 0.564). In all studies, mean kMMT accuracies were found to be significantly different from mean Intuition accuracies ($p \leq 0.01$), and from Chance ($p < 0.01$). On the other hand, no difference was found between grip strength following False statements compared to grip strength following True statements ($p = 0.61$). In addition, the Practitioner-TP complex accounted for 57% of the variation in kMMT accuracy, with 43% unaccounted for. Also, there was no difference in the mean kMMT accuracy when using emotionally-arousing stimuli compared to when using affect-neutral stimuli ($p = 0.35$). Mean sensitivities (95% CI) ranged from 0.503 (0.421 - 0.584) to 0.659 (0.612 - 0.706) while mean specificities (95% CI) ranged from 0.638 (0.430 - 0.486) to 0.685 (0.616 - 0.754). Finally, while a number of participant characteristic seemed to influence kMMT accuracy during one study or another, no one specific characteristic was found to influence kMMT accuracy consistently (i.e. across the series of studies).

Discussion: This series of studies has shown that kMMT can be investigated using rigorous evidence-based health care methods. Furthermore, for distinguishing lies from truths, kMMT has repeatedly been found to be significantly more accurate than both Intuition and Chance. Practitioners appear to be an integral part of the kMMT dynamic because when replaced by a mechanical device (i.e. a grip strength dynamometer), distinguishing Lies from Truth was not possible. In addition, since specificities seemed to

be greater than sensitivities, Truths may have been easier to detect than Lies. A limitation of this series of studies is that I have a potential conflict of interest, in that I am a practitioner of kMMT who gets paid to perform kMMT. Another limitation is these results are not generalisable to other applications of kMMT, such as its use in other paradigms or using muscles other than the deltoid. Also, these results suggest that kMMT may be about 60% accurate, which is statistically different from Intuition and Chance; however it has not been established if 60% correct is *"good enough"* in a clinical context. As such, further research is needed to assess its clinical utility, such as randomised controlled trials investigating the effectiveness of whole kMMT technique systems. Also, future investigators may want to explore what factors, such as specific Practitioner and TP characteristics, influence kMMT accuracy, and to investigate the validity of using kMMT to detect other target conditions, using other reference standards and muscles other than the deltoid.

Summary: This series of diagnostic test accuracy studies has found that kMMT can be investigated using rigorous methods, and that kMMT used to distinguish Lies from Truths is significantly more accurate that both Intuition and Chance. Further research is needed to assess kMMT's clinical utility.

This thesis is dedicated to

my father....

Thank you for teaching me perseverance.

"I am thankful to all those who said, 'No.'

Because of them I did it myself."

- Albert Einstein

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"At times our own light goes out and is rekindled by a spark from another person. Each of us has cause to think with deep gratitude of those who have lighted the flame within us."

— Albert Schweitzer

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TABLE OF CONTENTS

ABBREVIATIONS

AK	Applied Kinesiology (technique)
AK-MMT	Applied-Kinesiology-style manual muscle testing
ANEW	Affective Norms for English Words
ANOVA	analysis of variance
ANZCTR	Australian New Zealand Clinical Trials Registry
BEST	Bio Energetic Synchronization Technique
BSFF	Be Set Free Fast (technique)
C	congruent
CI	confidence interval
CK	Clinical Kinesiology
cm	centimetre
CRA	Contact Reflex Analysis (technique)
DMT	dynamometric muscle testing
DNFT	Directional Non-Force Technique
EBM	evidence-based medicine
ECU	European Chiropractors' Union
EEM	Eden Energy Medicine (technique)
EFT	Emotional Freedom Technique
F	false or female (as defined in text)
FN	false negative
FP	false positive
HK	Health Kinesiology
I	incongruent
IAPS	International Affective Picture System
kg	kilogram

kMMT	kinesiology-style manual muscle testing
KST	Koren Specific Technique
m	slope
MMT	manual muscle testing
MRT	muscle response testing
NAET	Nambudripad's Allergy Elimination Techniques
NET	Neuro Emotional Technique
NIS	Neurological Integration System (technique)
NMT	Neuro Modulation Technique
NOT	Neural Organization Technique
NPV	negative predictive value
NRT	Nutritional Response Testing (technique)
OA	osteoarthritis
OxTREC	Oxford Tropical Research Ethics Committee
PI	principal investigator
PIS	participant information sheet
PPV	positive predictive value
QRA	Quantum Reflex Analysis (technique)
ROC	receiver operating characteristic
S	strong
SD	standard deviation
SOT	Sacro Occipital Technique
STAI	State-Trait Anxiety Inventory
STARD	Standards for the Reporting of Diagnostic Accuracy
STO	Soft Tissue Orthopedics (technique)
T	true
TBM	Total Body Modification (technique)

TFT	Thought Field Therapy (technique)
TP	test patient
UK	United Kingdom
US	United States
VAS	visual analogue scale
W	weak

GLOSSARY

In this thesis, the following terms are used as defined:

accuracy	the amount of agreement between the results from the index test and those from the reference standard; specifically, in these studies, the overall fraction correct; see Figure 1.5.
affect	the feeling experienced in connection with an emotion.
analytical validity	a test's ability to accurately and reliably measure the entity of interest; answers the question: *"Is it true?"*
Applied Kinesiology	a specific intervention system which uses MMT not to evaluate muscular strength or power per se, but to evaluate the neural control of muscle function; its premise is that when there is some "aberrant nervous system input to a muscle," it is less likely to be able to resist an externally applied force, indicating some type of neurologic dysfunction, which then may be related to some altered physiological function, such as organ, endocrine or immune dysfunction; developed by Dr. George Goodheart in the 1960's.
arm response testing	see *kinesiology-style manual muscle testing.*
Chance	the hypothetical situation where either outcome was equally likely: 50-50.
clinical utility	a test's clinical value in relation to costs and patient outcomes; answers the question: *"Is it useful?"*
clinical validity	a test's meaningfulness to other related clinical data; answers the question: *"Is it meaningful?"*
congruent	in agreement with; one is "congruent" with a concept one believes to be true.
conscious / consciousness	the state of being *aware*; used interchangeably with *aware:* If one is *aware* of something, one is *conscious* of it, and vice versa.
deceit	concealment or distortion of the truth for the purpose of misleading.
diagnostic test	any process that yields information used to inform patient management; or alternatively, any method for obtaining additional information on a patient's health status.

dynamometric muscle testing	a test which quantifies MMT by recording the peak force generated by a muscle or a group of muscles when loaded in tension or compression; specifically grip strength dynamometric muscle testing.
eccentric contraction	a muscular contraction in which the muscle elongates usually while under load, where the muscle acts to decelerate the joint at the end of a movement.
efferent	carrying nerve impulses from the central nervous system to an effector, such as a muscle or organ.
facilitated muscle	a strong muscle; see *strong*.
false	not in accordance with what is generally accepted as true or factual.
glenohumeral joint	the ball-and-socket joint which is part of the shoulder joint complex.
Hawthorne Effect	the alteration of behavior by the participants of a study due to their awareness of being observed.
incongruent	not in agreement with; one is “incongruent” with a concept that one believes to be untrue.
indicator muscle	in AK and other kMMT techniques, the muscle used for testing; commonly the deltoid, psoas or pectoralis muscles.
inhibited muscle	a weak muscle; see *weak*.
Intuition	a Practitioner’s ability to “read” a TP, using only the senses (i.e. vision, hearing, touch) without the use of kMMT.
to intuit	to "read" a TP, using only the senses (i.e. vision, hearing, touch) without the use of kMMT.
isometric contraction	a muscular contraction characterised by increase in tension without change in muscle length or joint angle.
kinesiology	see *kinesiology-style manual muscle testing.*

kinesiology-style manual muscle testing	a non-invasive assessment method used to obtain additional information about a patient's health status by applying an external force to an "indicator" muscle; while the patient holds a specific joint in a fixed position (usually in partial flexion), the practitioner-applied pressure first causes an isometric and then an eccentric contraction; the test is binary with outcomes labelled as "weak" or "strong" based on its ability to resist the practitioner-applied force; see *indicator muscle*, *weak* and *strong*.
Likert Scale	an ordinal psychometric measurement used to quantify attitudes, beliefs or opinions;
lying	a false statement made with deliberate intent to deceive; an intentional untruth.
manual muscle testing	the general term for a non-invasive assessment method used to evaluate neuromusculoskeletal integrity; a fundamental component of physical examinations performed by physiotherapists, chiropractors, osteopaths and some medical specialists; if not otherwise specified, refers to Kendall-and-Kendall / orthopaedic muscle testing only, and does *not* refer to kMMT.
meridian	in acupuncture and Chinese medicine, each of a set of pathways in the body along which vital energy ("chi") is said to flow; it is said that there are twelve such pathways associated with specific organs.
muscle checking	see *kinesiology-style manual muscle testing.*
muscle monitoring	see *kinesiology-style manual muscle testing.*
muscle power	a muscle's ability to generate as much force as fast as possible; Power = Work/Time.
muscle response testing	see *kinesiology-style manual muscle testing.*
muscle strength	the ability of a muscle or muscle group to exert force to overcome a resistance with no concern for time; Strength = Mass * Distance; it is the result of 3 factors: (1) physiological strength (muscle size, cross sectional area, available cross bridging, responses to training), (2) neurological strength (how strong or weak is the signal that tells the muscle to contract), and (3) mechanical strength (muscle's force angle on the lever, moment arm length, joint capabilities).
muscle testing	see *kinesiology-style manual muscle testing.*

naïve (or kMMT-naïve)	having no prior experience with kMMT.
negative predictive value	the chance that if kMMT stayed strong that the statement was True.
nonconscious	all that which is not conscious; and inherently different to what has been described as "subconscious" or "unconscious" in other contexts; see *conscious / consciousness.*
Pair	refers to the Practitioner-Test Patient dyad.
positive predictive value	the chance that if kMMT went weak that the statement was a Lie.
Practitioner	the participant who is performing the kMMT.
precision	the degree to which repeated measurements under unchanged conditions show the same results; see *Figure 1.5*.
repeatability	the closeness of the agreement between independent results obtained with the same method on the identical subject(s), under the same conditions; or the variability of the measurements obtained by one person while measuring the same item repeatedly (intraobserver variability).
reproducibility	the closeness of the agreement between independent results obtained with the same method on the identical subject(s) but under different conditions; or the variability of the average values obtained by several observers while measuring the same item (interobserver variability).
semantic stimuli	stimuli which consist of language, such as words and phrases; such as a spoken statement.
sensitivity	the proportion of the Lies that were detected.
specificity	the proportion of the Truths that were detected
STARD	guidelines developed to improve the quality of reporting of studies of diagnostic test accuracy, consisting of the statement, a checklist, flowchart and an explanation/elaboration document.
strong	a muscle which is able to resist a practitioner's downward pressure.
surrogate	in the case that a patient's muscle/s cannot be tested (e.g. infants), tested instead are the muscles of a substitute, who is often in close proximity to and / or touching the patient, but not always.

Test Patient	the participant upon whom the kMMT was being performed.
true / truth	that which is generally accepted as fact or reality.
valence	(used in psychology, especially in discussing emotions) the intrinsic attractiveness (positive valence) or aversiveness (negative valence) of an event, object, or situation.
weak	a muscle which is ***unable*** to resist a practitioner's downward pressure.

CHAPTER 1

Introduction

"Truth will ultimately prevail where there is pains to bring it to light."

George Washington

CHAPTER 1 : INTRODUCTION

Manual muscle testing (MMT) is a non-invasive assessment method used to evaluate neuromusculoskeletal integrity,[1] and is a fundamental component of physical examinations performed by physiotherapists, chiropractors, osteopaths and some medical specialists.[2] Different health professionals use MMT for different purposes, and as a result, there exists some confusion surrounding the term itself, and how the tests are performed and interpreted. Consequently, research efforts to assess the validity and clinical utility of MMT have been difficult to design, to conduct and even to understand; and as a result, its usefulness as an assessment method has been called into question.[3-6]

1.1 The Evolution of MMT

First described in the literature in 1915 by Lovett and Martin, MMT was originally used to assess muscular weakness in polio patients.[7, 8] The tests were crude and unspecific, and little was known about their validity.

In 1949, in their benchmark textbook, Muscles: Testing and Function, Kendall and Kendall outlined specific methodologies to isolate and test individual muscles or muscle groups.[1, 9, 10] Currently, it is this type of MMT that is used in orthopaedic and neurology settings to assess neuromusculoskeletal integrity. This form of MMT usually tests for muscular strength or power, and outcomes are typically graded from 0 to 5, and interpreted as 5 being normal.[7, 10]

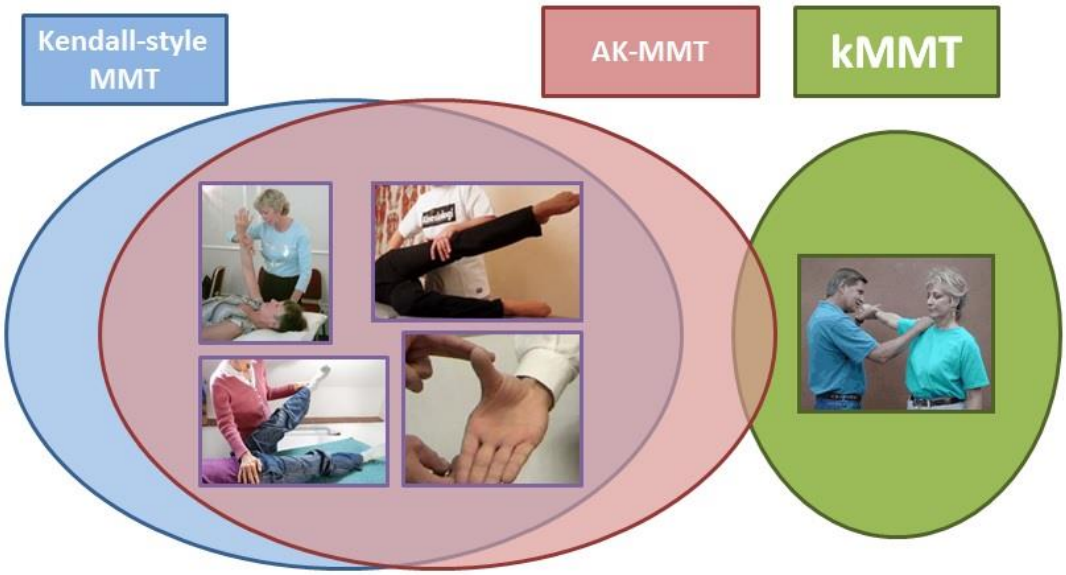
In the 1960's, a different use for MMT was developed by a chiropractor, Dr. George Goodheart.[11] In Goodheart's technique, called Applied Kinesiology (AK), which is practiced by approximately 40% of American chiropractors,[12, 13] specific muscles are tested (similar to Kendall and Kendall), not to evaluate muscular strength or power per

se, but to evaluate the neural control of muscle function.[11] The basic premise of AK is that when there is some "aberrant nervous system input to a muscle," it is less likely to be able to resist an externally applied force.[11] Therefore, target conditions of AK-style MMT (AK-MMT) include various types of neurologic dysfunction, such as a sciatic neuropathy or Bell's Palsy,[14] which then may be related to some altered physiological function, such as organ, endocrine or immune dysfunction.[11, 15-18] However, both the origin(s) and the cause(s) of this irregular neurological input are yet unclear and fervently debated.[19-22] One other notable difference between AK-MMT and the Kendall-style MMT is that in the AK-style, the outcome is binary, and usually labeled "strong" (or "facilitated") or "weak" (or "inhibited").[11] So with this divergence in the 1960's, various approaches toward MMT began to emerge. While the tests may be similar in appearance, both the purpose of performing the tests and the interpretation of the test results differ significantly.

FIGURE 1.1 – The evolution of manual muscle testing (MMT).

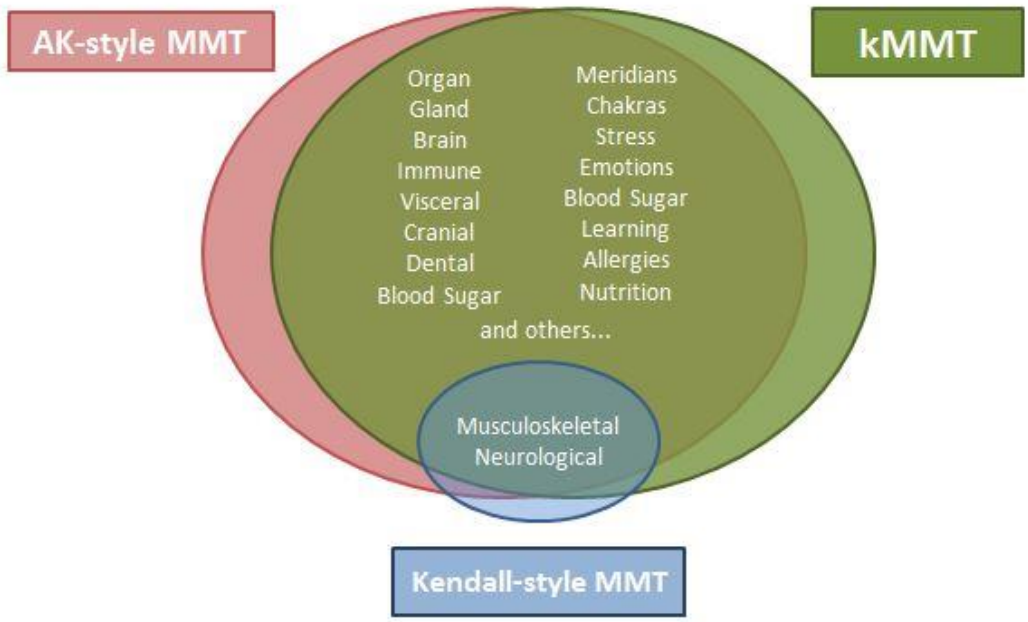
Following on from Goodheart's work, a third type of MMT emerged (see Figure 1.1). This third form, which I will refer to as "kinesiology-style MMT" (kMMT), is estimated to be used in over 70 different therapeutic technique systems (see Appendix C, page 360), and by over 1 million practitioners worldwide (see Appendix C, page 360). While it is often referred to colloquially as simply "muscle testing," it has also been referred to by other names, such as "kinesiology[i]," "muscle response testing," "arm response testing," "arm testing," "the arm push down test," "muscle checking," "muscle monitoring," and others. Examples of technique systems that use kMMT include, but are not limited to: BodyTalk, Contact Reflex Analysis® (CRA), Neuro Emotional Technique® (NET), PSYCH-K®, and Total Body Modification™ (TBM). For further clarification of the different types of MMT, see Figures 1.2 and 1.3.

FIGURE 1.2 – Performance of the MMT : This Venn Diagram describes how the 3 kinds of MMT are performed. There is little difference between Kendall-style and AK-MMT, but how kMMT is performed primarily deviates from both.



[i] It may be useful here to note that there are now two other disciplines that use of the term "kinesiology:" (1) "Kinesiology" as in the study of human movement [Twietmeyer G. What is kinesiology? Historical and philosophical insights. *Quest* 2012; 64(1): 4-23.], and (2) "Kinesiology Taping" in the field of Physiotherapy / Physical Therapy [Kahanov L. Kinesio taping®, part 1: An overview of its use in athletes. *Athletic Therapy Today* 2007; 12(3): 17-8.] Both are from different fields altogether, and not related to kMMT.

FIGURE 1.3 – Target conditions of MMT: This Venn Diagram describes common target conditions (i.e. dysfunctions) of the 3 kinds of MMT. The Kendall-style MMT only tests for neuromusculoskeletal dysfunction, while AK-style and kMMT are used to test many more conditions.



To be clear, it is the third generation of MMT, kMMT, which is of interest to this research student and the subject under investigation in this series of diagnostic test accuracy studies. Therefore, I relinquish further description of the other forms of MMT, and will now focus exclusively on kMMT.

1.2 The kinesiology-style Manual Muscle Test

A kinesiology-style manual muscle test is distinctly different in a number of ways from its predecessors:

(1) kMMT is not as specific as either the Kendall-style or the AK-style of MMT;

(2) its applications and interpretations of results are not standardised;

(3) normally only one muscle, commonly called "the indicator muscle," is used for testing for various target conditions;

(4) the amount of force applied to the indicator muscle is also not standardised, with variations ranging from a great deal of pressure to an amount barely perceivable;
(5) the indicator muscle is tested repeatedly as the target conditions change; and finally,
(6) which muscle is used as the indicator muscle is of little significance.

This last point means that it is not the specific muscle that is of importance, but what the practitioner is testing for (i.e. the target condition) that is `fundamental. In other words, once the practitioner decides on the target condition and the interpretation of the outcomes, he can use any indicator muscle to conduct the test. Which indicator muscle used may vary with kMMT technique system and practitioner preference, however, the anterior or lateral deltoids, the hamstring, the latissimus dorsi or the pectoralis major muscles are often used.

Nevertheless, kMMT does have some similarities to the other forms of MMT as well. For instance, its basic premise is comparable in that users contend that alterations in efferent nervous stimulation into a muscle, will cause the muscle to weaken.[23, 24] And again, the cause(s) and source(s) of these alterations are yet unclear. Another similarity is that patients are asked to resist the practitioner's applied pressure in an analogous way.

During a kMMT, an external force is likewise applied to a muscle. At first, this practitioner-applied pressure causes an isometric[ii] then an eccentric[ii] contraction. More explicitly, during a kMMT, the patient holds a specific joint in a fixed position, usually in partial flexion. The practitioner then applies pressure, usually into extension, as the

[ii] ***Isometric contraction***: muscular contraction not accompanied by movement of the joint; ***Eccentric contraction***: a muscular contraction in which the muscle elongates usually while under load, where the muscle acts to decelerate the joint at the end of a movement. (*Mosby's Medical Dictionary,* 8th edition. Oxford, UK: Elsevier, 2009.)

patient resists this pressure using an isometric contraction. For example, the practitioner may ask the patient to hold his shoulder (i.e. the glenohumeral joint[iii]) in 90^{o} flexion, palm facing down, while he tests the anterior deltoid (see Figure 1.4A). Where the practitioner places his own hand for the application of the force into extension is often a matter of contention,[9] but the location is routinely on the distal forearm of the patient, just proximal to the wrist joint (see Figure 1.4.B), with the elbow held in full and locked extension. Some muscle testing practitioners disagree with this placement, as it contradicts Kendall's convention of testing one joint at a time,[1] since pressure is being applied to both the shoulder and elbow joints simultaneously. The degree of shoulder flexion and abduction and elbow flexion may vary, as do the placement of the practitioner's testing hand and his non-testing hand. Finally, while the degree of pressure that the practitioner applies may differ widely, a steady and constant pressure is thought to minimise bias, whereas abrupt and inconsistent pressure is thought to introduce bias into the test.

FIGURE 1.4 – Kinesiology-style Manual Muscle Testing (kMMT): (A) An example of one style of kMMT, (B) An example of where a practitioner might place his or her hand on a patient's wrist.

(A) (B)

[iii] The Glenohumeral Joint is part of the shoulder joint complex.

Similar to AK-MMT, the test result of kMMT is binary, with the muscle being tested also customarily labelled "weak" or "strong" based on its ability to resist the practitioner-applied force.[25] Previous research has established that there *is* a significant difference between "strong" muscles and "weak" muscles during a muscle test.[3, 25-29] Therefore, in this series of studies, I have not re-examined *if* there is a difference, but instead, I have focused on the gap in the literature: if this difference can be used in an accurate and clinically meaningful way.

1.3 Applications of kMMT

In this section, I will briefly outline a number of applications of kMMT, or more explicitly, some target conditions which muscle testing practitioners regularly test for using kMMT. Because kMMT is used to assess for various target conditions, its accuracy must be considered, and therefore, for clarity, I define ***accuracy*** as, "the amount of agreement between the results from the index test and those from a reference standard."

Within the 70+ technique systems that use kMMT, there exists literally hundreds of potential target conditions, ranging from physiological dysfunction to meridian imbalance to a patient's level of stress, and others. See Figure 1.3.

For example, in a review of the literature, kMMT was found to accurately predict low back pain[30], simple phobia,[31] and food allergies.[32] On the other hand, other studies found that MMT was unable to accurately predict nutritional needs,[33-35] nutritional intolerance,[33, 36] thyroid dysfunction,[37] exposure to a practitioner-defined noxious stimulus,[33, 38] and chiropractic subluxation detection and correction.[39] Irrespective of these studies failing to demonstrate sufficient accuracy, practitioners still routinely use kMMT to attempt to detect these conditions.[24, 40]

There are many other examples of target conditions regularly tested for using kMMT that are not yet supported by clinical research. For instance, in the first course of one popular kMMT technique system called Total Body Modification (TBM), practitioners are taught to use kMMT to identify depression, anxiety, organ-centered problems, blood sugar problems, autonomic nervous system dysregulation, and overall health status.[41] In addition, another kMMT technique, Neuro Emotional Technique® (NET), also teaches protocols that use kMMT to assess for emotional stress, blood sugar irregularities, and meridian imbalance.[42] Like NET, another widely-practiced technique called Touch for Health, uses kMMT to assess for emotional stress and meridian imbalance, and also for food allergies and the need for nutritional supplementation.[43, 44]

The wide range of applications and heterogeneity of protocols of use of kMMT contribute to the difficulties of undertaking rigorous trials on the clinical utility of kMMT. Plus, the varying interpretations of its outcomes have caused further confusion, which also must be addressed.[9]

1.4 Interpreting the outcome of the kMMT

The interpretation of the outcome of a muscle test is not consistent throughout kMMT techniques. In most kMMT techniques, the practitioner decides the outcome of the kMMT,[22-24] however, in PSYCH-K[45] and some others, the client decides. The outcome is usually labeled “strong” if the muscle is able to resist the practitioner’s downward pressure and “weak” if it is unable to resist the pressure. Consequently, the outcome of the kMMT is binary (“strong” or “weak”) and is interpreted to denote the presence or absence of a target condition. However, in some applications of kMMT, a strong result could indicate the presence of the target condition, and in other applications of kMMT, a

strong result could indicate the absence of the very same target condition. This can easily lead to confusion and misinterpretation both in practice and research. Therefore, it becomes imperative that those doing the testing be clear about the target condition for which they are testing, and also about the meanings of the potential outcomes of the test. Consequently, the target condition and the interpretation of the test outcome must be specifically identified prior to the initiation of the kMMT.

For these reasons, and because the target condition can literally change from one kMMT to the next, designing diagnostic test accuracy studies for kMMT can be challenging. Therefore, for kMMT studies to be meaningful, careful consideration must be given to the choice of target condition, to the interpretation of the test outcome, and to the choice of reference standard.

1.5 The Current Status of the Evidence

Until the development of the Standards for the Reporting of Diagnostic Accuracy (STARD) guidelines in 2003, the evaluation of diagnostic techniques lagged behind that of interventions, and had been notoriously fraught with inconsistencies and bias.[46, 47] This is especially true about the inconsistent use of terminology used to describe the usefulness of a diagnostic test: Various terms (e.g. accuracy and precision) are confused in colloquial English, and at times in the scientific literature as well.[48] In assessing the current status of the kMMT literature, this difficulty is further amplified by the confusion about the terms “muscle testing” and “kinesiology” – which, as previously described, can have different meanings in different contexts.

With this in mind, using the electronic databases MEDLINE, MANTIS, *PsycINFO*® and CINAHL, a literature search was conducted, firstly narrowly, and then broadening. At

first, I searched for papers that only used kMMT to detect lies (or truths), then I widened the search to include papers that used kMMT to detect anything, and then I widened it further to include papers that also used AK-MMT to detect anything. Since Kendall & Kendall MMT is just used to detect neuromusculoskeletal dysfunction, I ruled out searching for papers that used this type of muscle testing. The outcome of my search was 25 papers from peer-reviewed journals that used either kMMT or AK-MMT to detect a specified target condition. Since research on MMT described in conference proceedings was found to lack or to fail to report rigorous methods,[49] only papers published in peer-reviewed journals were considered. The reference lists of the included papers were also checked for relevant research, which resulted in no additions. For a complete description of search strategy, see Appendix Table B.1.1.

Few rigorous studies have attempted to estimate the accuracy of kMMT or AK-MMT. On the other hand, there are numerous studies that have looked as other characteristics of MMT, such as reliability,[50-56] validity,[50, 54, 57] inter-examiner agreement,[6, 55] intra-examiner agreement,[56, 58] predictability,[30, 59] internal consistency,[60] and diagnosis in general.[34, 36, 37, 61-64] The appropriateness of the use of some of these analyses in regards to kMMT or AK-MMT is questionable, and the sheer number of terms used to describe its usefulness is frankly confusing.

However, there are some published studies that do report accuracy estimations. Using the AK-style of MMT, Caruso and Leisman[13] report experienced practitioners (≥5 year experience) predicted muscle strength more accurately compared to inexperienced practitioners (<5 year experience), with accuracies of 98% and 64%, respectively. In other studies it was found that kMMT was used to accurately predict low back pain[27] and simple phobia,[28] and AK-MMT accurately predicted food allergies.[29] On the other hand,

further studies found that AK-MMT was unable to accurately predict nutritional needs,[30-32] nutritional intolerance,[30,33] and thyroid dysfunction.[34]

Nevertheless, one study used kMMT to differentiate between true and false statements. Monti et al.[25] found that when a muscle is tested following a true spoken statement, it yields significantly different results compared to kMMT following false spoken statements. Their study found that the indicator muscle stays "strong" after a patient speaks true statements and goes "weak" after a patient speaks false statements. Their statements were self-referential statements, which used the speaker's name, as in, "My name is (insert one's name or another name)".[25] One problem with using self-referential statements is that, in all likelihood, both the muscle tester and the test patient were aware of the verity of the statement, and therefore, both were not blind.[iv] Even though examiner bias was controlled for in Monti's study,[25] there is a chance that unblinded testing may introduce other biases and thus influence the test's outcome. While it is generally accepted among those who use various types of MMT that some bias can exist, little is currently known about the degree of this bias.

1.6 kMMT as a "Diagnostic Test?"

Some may question the appropriateness of using the term "diagnostic test" in regard to kMMT. A diagnostic test can be described as "any process that yields information used to inform patient management,"[65] or alternatively "any method for obtaining additional information on a patient's health status."[66] Since kMMT is used both to obtain

[iv] Blinding of the muscle testers was not specifically reported in Monti's paper. [Monti, D.A., et al., *Muscle test comparisons of congruent and incongruent self-referential statements.* Perceptual and Motor Skills, 1999. 88(3): p. 1019-1028.]

information about a patient and to guide treatment, kMMT would indeed qualify as a diagnostic test.

Regarding diagnostic tests, two different approaches have emerged. On one hand, in medicine, a diagnostic test is used to differentiate people with a specific disease from those without that specific disease,[67] and the result of the test is usually binary[v].[68] That is, the condition or disease is either present or absent.[69] On the other hand, in psychology and education, test outcomes are typically graded according to how much of a specific attribute a patient experiences,[68] such as mild, moderate or severe anxiety. Therefore, variables are ***not*** normally binary, but instead fall along continua.[68, 69]

In either case, in order for the test results to be useful, the assessment method must have certain characteristics: It must measure what it claims to measure, and it must do this consistently. With psychometrics, the terms "valid" and "reliable" are used in regard to the former and latter, respectively.[70] In contrast, medical diagnostic tests are referred to as being "accurate," and "precise" or "repeatable."[71]

Finally, used in conjunction with a thorough history and clinical examination, diagnostic tests can help lead to a diagnosis and therefore, guide the course of treatment.[71, 72] Nonetheless, it is acknowledged that no medical "diagnosis" is made from the results of a muscle test; rather, practitioners use kMMT to formulate a clinical impression of a patient's condition. Furthermore, in clinical practice, multiple kMMTs are performed in series before any clinical impression is even considered.

[v] It is noted that many medical tests are reported as continua initially, yet when diagnosing, a "cut off" mark is established, whereupon a patient either has or does not have a certain condition; therefore, ultimately the test becomes binary.

In light of these considerations, it would be more appropriate to use the medical terminology, rather than the psychometric terminology. It would also be appropriate to consider kMMT a diagnostic test and use the methods of diagnostic accuracy studies and the corresponding terminology. Furthermore, since the evaluation of kMMT as a diagnostic tool is in its early stages, it is appropriate to start with estimating its accuracy (overall fraction correct), sensitivity, specificity and precision (reproducibility and repeatability) in a controlled setting.[73] Subsequent studies will be needed to focus on its clinical utility, or if kMMT is useful in improving or maintaining the health of patients.[73]

Accordingly, this series of studies have estimated the accuracy and precision of kMMT [46], and the STARD Statement have been used to report the results (see Appendix D, page 370).[74]

1.7 Diagnostic Accuracy of kMMT

Accuracy refers to the overall quality of the test.[75] A perfectly accurate test (100% accuracy) would correctly identify all persons in a sample who have the target condition, and would not wrongly identify anyone in the sample as having the condition when they did not.

While there are many ways to quantify the accuracy of a diagnostic test,[73] I chose as the primary outcome of many of the studies in this series, the overall fraction correct of using kMMT to detect lies. Experts in the field of diagnostic accuracy have questioned the usefulness of overall fraction correct, or simple "accuracy."[74-76] This is because with most medical conditions, the difference in importance between a false positive and a false negative test result could be critical.

In this series of studies assessing the diagnostic accuracy of kMMT, not only am I asserting that true positives are equal in importance to true negatives, I am also asserting that the significance of false positives is equivalent to that of false negatives. However, future research may prove this not to be the case.

In medical testing, there are more common ways of quantifying the accuracy of a diagnostic test other than by reporting overall fraction correct, such as sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).[73, 75] For completeness, in many cases I will be reporting these estimations as well, however, their meanings might need clarification within the context of kMMT:

Sensitivity = The proportion of the Lies that were detected

Specificity = The proportion of the Truths that were detected

PPV = The chance that if kMMT went weak that the statement was a Lie

NPV= The chance that if kMMT stayed strong that the statement was True

In theory, kMMT would be considered perfectly accurate if it could be used to identify all false statements as being false and all true statements as being true. While it is generally accepted that no practitioner-interpreted assessment tool is 100% accurate and totally bias-free, it is clear that the clinical validity of kMMT has not yet been firmly established. It is hoped that through these studies, the usefulness of kMMT will become more evident.

1.8 Diagnostic Precision of kMMT

A diagnostic test is considered valid if it is both accurate and precise; therefore, an in depth look at the precision of kMMT is in order as well.

Colloquially, the terms accuracy and precision are often used interchangeably. Where accuracy is defined as "the amount of agreement between the results from the index test and those from the reference standard,"[66] precision can be defined as "the degree to which repeated measurements under unchanged conditions show the same results."[77] For clarification of the difference between accuracy and precision, see Figure 1.5. Some medical statisticians look at a test's confidence intervals when determining its precision.[78] Other medical researchers think of precision in terms of *reproducibility* or *repeatability*, two terms which are also frequently confused. For clarity, each is defined as:

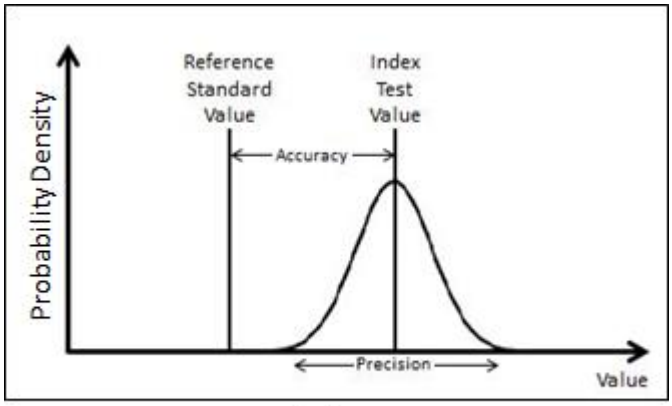
> *Reproducibility*, the closeness of the agreement between independent results obtained with the same method on the identical subject(s) but under different conditions… or it is the variability of the average values obtained by several observers while measuring the same item (interobserver variability).[48]
>
> *Repeatability*, the closeness of the agreement between independent results obtained with the same method on the identical subject(s), under the same conditions… or it is the variability of the measurements obtained by one person while measuring the same item repeatedly (intraobserver variability).[48]

The inconsistency of terminologies is not uncommon in scientific literature.[48] The use of imprecise terms undermines the rigorousness of methods, hinders the interpretation of results, and hence, weakens the credibility of conclusions.[11, 48, 75] Since a good deal of ambiguity already surrounds kMMT, special care was taken to define terms explicitly.

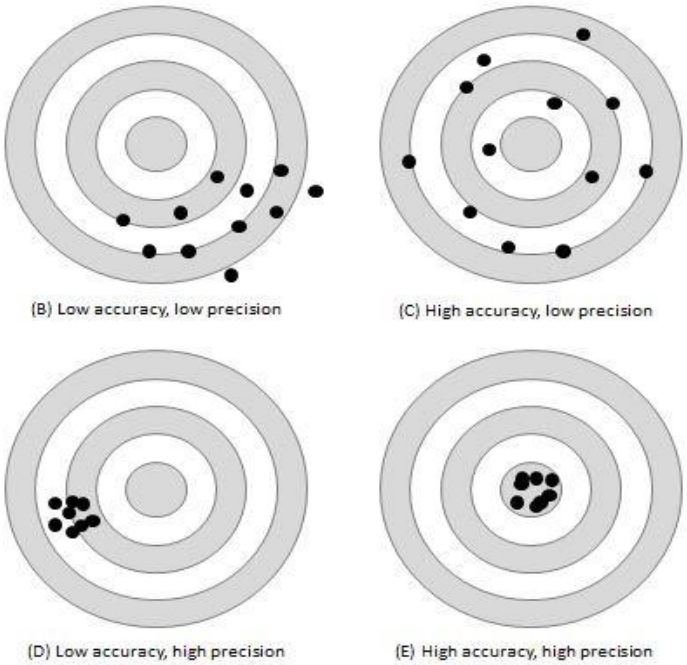
Applying these terms to kMMT, I designed a study that could be used to estimate its precision both in terms of reproducibility ***and*** repeatability. In designing this study, I was

curious if a Practitioner's kMMT accuracy was consistent over many Test Patients (TPs), or if it was TP- or pair-specific; and likewise, if the kMMT accuracy obtained with one TP was consistent over many Practitioners, or if it was Practitioner- or pair-specific. For further details about this study, see Chapter 5.

FIGURE 1.5 – Accuracy & precision in diagnostic tests. (A) Accuracy vs. precision using a graph; (B-E) Comparing accuracy vs. precision using a target metaphor.



(A)



(B)

1.9 Choice of Research Topic

When I began my PDhil, I initially wished to assess the effectiveness of a new stress reduction technique for minor depressive disorder (a mood disorder).[79] However, this technique uses kMMT to distinguish truth from lies, which in turn guides the therapy. Since the validity of kMMT for distinguishing truth from lies had not been established, I was encouraged first to evaluate the accuracy of kMMT used in this manner. I, therefore, launched a thorough investigation into studies of diagnostic test accuracy and how they might be applied to kMMT.

1.10 Research Question and Paradigm to Investigate

Since I was interested in exploring if kMMT can accurately distinguish truth from lies, I chose as my target condition *deceit*. Therefore, my research question became: *Can kMMT be used to accurately detect lies?*

I could have chosen *truth* as my target condition; indeed, it is my perception that clinically, kMMT is used just as often to detect truths as lies. In fact, for a period of time, I was convinced that I should be targeting *truth*, since I am usually in pursuit of *the truth*. However, after a number of vigorous debates with my supervisors, I was persuaded that lie detection was a more useful construct in the context of the intervention mentioned above. So, *deceit* is the target condition in this series of diagnostic test accuracy studies.

Since test accuracy is largely dependent upon how the target condition and reference standard are defined,[80] great care also was taken in defining the terms *truth*, and subsequently *deceit*, as they were used in these studies. Had the definitions been ambiguous, the test results would not have been able to be interpreted meaningfully, limiting the ability to use and interpret the test in a clinical context.

In the following series of studies, *deceit* is the target condition and the studies test whether kMMT was useful in distinguishing lying from truth. Here, "truth" refers to the colloquial usage of the term: *that which is generally accepted as fact or reality*.[81] (This is as opposed to abstract concepts of "truth," such as "the Universal Truth" or "the Higher Truth."[22]) In contrast, "lying" refers to the opposite of "truth," or more specifically: *a false statement made with deliberate intent to deceive; an intentional untruth; a falsehood*.[82] It may be useful to emphasise here that lying implies *an intent to deceive*, and in the context of the five studies presented within, it is asserted that test patients are consciously aware when they are indeed lying and when they are telling the truth. This therefore may not represent all situations in clinical practice, for example, where patients are not consciously aware of the truth or falsity of statements. Since testing for nonconscious[vi] beliefs occurs in clinical practice, [24, 42, 83] it is, therefore, a legitimate avenue of research.[84] However, the utility of nonconscious beliefs is not explored in this series of studies, as I thought it important to establish the utility of kMMT for detecting conscious untruths before introducing an additional level of complexity into the research. Throughout this series of diagnostic test accuracy studies, therefore, the target condition is *conscious deceit by the test patient*.

It is widely accepted that lying is a stress which may cause observable changes in physiology, some clearly discernable, such as blushing, others less apparent.[85, 86] A number of different technique systems use kMMT to explore the body's physiological response to semantic stimuli,[25] which may include both cognitive and emotional components. The semantic stimuli can be spoken statements,[23, 24] questions,[22] or

[vi] The term "nonconscious" can be described as *all that which is not conscious,* and is inherently different to what has been described as "subconscious" or "unconscious" in other contexts. [LeDoux, J.E., *The emotional brain: The mysterious underpinnings of emotional life*. 1996, New York: Touchstone.]

concepts.[24] I chose to test a commonly used paradigm among muscle testing practitioners in this series of studies which is: when a patient believes a spoken statement to be ***true***, then in response to a kMMT, the muscle will stay "strong;" and when a patient believes the statement to be ***false***, the muscle will become "weak." [In this paradigm the patient is the one speaking the statements, and the practitioner performs the muscle test immediately afterwards.] (See Table 1.1 for a summary of the paradigm.)

TABLE 1.1 – Summary of kMMT paradigm under investigation in this series of studies

Test Patient's Spoken Statement	Expected Result of kMMT
TRUE	STRONG
FALSE	WEAK

kMMT, kinesiology-style Manual Muscle Testing

This paradigm was selected from hundreds of potential paradigms presently used in clinical kMMT practice for a number of reasons. Firstly, I regularly use this paradigm in practice myself, as do tens of thousands of other muscle-testing practitioners around the world. Secondly, on a logical level, distinguishing lies from truths is relatively straightforward: *something is either true or it is not*. Therefore, the valence is clear. This means that a clear reference standard, indeed a gold standard, is possible.

As the legitimacy of kMMT is often called into question,[9, 21, 33, 34, 87-95] a rigorously-designed series of diagnostic test accuracy studies using a gold standard reference test may resolve the debate, one way or the other. For all these reasons, this paradigm was the obvious choice as a starting point for this line of research.

1.11 Choice of Populations

The choice of populations for this series of studies was also given careful consideration. The process of kMMT takes two individuals (usually[vii]), the Practitioner and the TP, dynamically enmeshed in a close therapeutic relationship. Because of this, it was conceived of early in the study design that there would be two distinct populations: (1) Practitioners, or those performing the kMMT, and (2) Test Patients, upon whom the kMMT was being performed, and together they would form one unique "pair."

Despite my initial objections, it was decided that recruitment of TPs would target healthy individuals with no prior kMMT experience. I initially objected because this does not represent a true clinical setting, since most patients of kMMT practitioners ***do*** have prior experience with kMMT and present with a specific complaint (i.e. are "unhealthy" in some way). However, scientific convention that "blind is better" won in the end and kMMT-naïve TPs were sought.

For Practitioners, health care providers would be the obvious population, but I deliberated whether to include ***any*** practitioner – or only those with kMMT training. In the pilot study, ***any*** practitioner was enrolled, regardless of having had any kMMT-training, and the results suggested that the kMMT accuracy of non-trained practitioners was no better than Chance, so in these studies, only kMMT-trained practitioners were recruited to perform the testing – regardless of technique, training, or profession. In order to get a true flavor of what was actually happening in clinical practice, a wide net was cast.

[vii] Some kMMT applications purportedly can be done on oneself through self-testing, but a discussion about self-testing goes beyond the scope of this dissertation.

1.12 Main Study Aims

Diagnostic tests are used to detect the presence or absence of a target condition,[80] and in studies of diagnostic test accuracy, the results of one test (i.e. The Index Test) are compared to the results of a Gold or Reference Standard Test, in the same population, and the amount of their agreement at detecting the target condition is estimated. In these studies, the target condition is "lying," kMMT is the primary Index Test, and the actual verity of the spoken statement can be considered a Gold Standard, since its presence was definitively known.

The main objective of this series of studies was to estimate the accuracy (overall fraction correct) and precision of kMMT to distinguish false from true statements under varying conditions.

Since kMMT styles vary widely from practitioner to practitioner and from technique system to technique system, a further goal of these studies was to test its accuracy in as close to a real clinical setting as possible, by using a variety of practitioner types and allowing each practitioner to choose his own kMMT style, while adhering to the same study methods. The characteristics of the stimuli presented varied from affect-neutral to emotionally-charged to subliminal. The target condition remained constant: *deceit*. The gold standard test remained constant: actual verity. To these ends, I present a series of five studies of diagnostic test accuracy using kMMT.

1.13 Chapter 1 – List of Tables and Figures

1.13.1 Tables

1.13.2 Figures

CHAPTER 2

Study 1 – Estimating the Accuracy of kMMT

"All truths are easy to understand once they are discovered;

the point is to discover them."

Galileo Galilei

CHAPTER 2 : STUDY 1 – ESTIMATING THE ACCURACY OF KMMT

2.1 ABSTRACT

Research Objective: To estimate the accuracy (overall fraction correct) of kinesiology-style manual muscle testing (kMMT) to distinguish lies from truth in spoken statements, with varying degrees of blinding.

Methods: A prospective study of diagnostic test accuracy was carried out. Forty-eight Practitioners who routinely practised kMMT were paired with kMMT-naïve Test Patients (TPs) and performed 60 kMMTs as TPs spoke True and False statements. Blocks of kMMT alternated with blocks of Intuition. Other conditions, such as Not-blind and Practitioner Misled were also introduced. Bias was controlled for using varying degrees of blinding and randomisation of True and False statements.

Results: kMMT accuracy was found to be 0.659 (95% CI 0.623 - 0.695), while Intuition accuracy was 0.474 (95% CI 0.449 - 0.500), which were significantly different ($p<0.01$). When the mean accuracy of kMMT was compared to the likelihood of Chance (0.500), a significant difference was also achieved ($p<0.01$). Testing for various factors that may have influenced kMMT accuracy failed to detect any correlations.

Summary: kMMT had significant accuracy for distinguishing lies from truths, compared to both Intuition and Chance. However, despite tracking on a variety of participant characteristics, no factor was identified that influenced kMMT accuracy. Strengths of this study include a high degree of blinding, the heterogeneity of the samples, the choice of a

clear target condition, and the choice of a “gold standard” reference standard, while the main limitation was its lack of generalisability to other applications of kMMT.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; lie detection; deception; lying; intuition; arm; upper extremity

2.2 Introduction

As mentioned in Chapter 1, kinesiology-style Manual Muscle Testing (kMMT) is estimated to be used by over 1 million practitioners worldwide in hundreds of applications and for a vast range of target conditions. Yet despite this prevalence, the validity of kMMT as a diagnostic test has not been clearly established. According to Bossuyt, early evaluations of a test should focus on answering the question, "Can I trust the results of this test?"[73] This is commonly known as a test's analytical validity, or its ability to measure what it is supposed to measure.[73] So this chapter describes my first study in a series of five diagnostic test accuracy studies and is primarily focused on answering this fundamental question in as general a setting as feasibly and reasonably practicable. The main purpose was to estimate the accuracy (i.e. overall fraction correct) of kMMT for detecting lies.

Previous diagnostic studies of kMMT have been conducted with mixed results. One study using a similar clinical application found that kMMT is able to distinguish true statements from false statements: They found a muscle is able to resist significantly more force after speaking true statements compared to after speaking false statements; that is, true statements result in a "strong" muscle response, while false statements result in a "weak" muscle response.[25] However, the degree of practitioner and/or test patient blinding in this study is unclear, leaving a gap in the literature. Therefore, another aim of this first study was to fill this gap by attempting to estimate kMMT accuracy using clearly differentiated blind and not-blind conditions.

Additionally, it is widely accepted that there are specific physiological events that spontaneously occur when someone is lying, such as changes in facial expressions, body language, speech qualities and skin dampness.[96, 97] Therefore, it is possible that it is not

the kMMT itself that allows practitioners to differentiate lies from truth; they may simply be proficient at detecting these physiological changes in patients. Therefore, a further aim of this study was to control for this possibility. To this end, a second index test was enacted, where practitioners were asked to detect the verity of spoken statements *without using kMMT*. That is, they were asked to "intuit" the verity of the spoken statement, using only visual, auditory and kinesthetic clues. Hence, the Intuition condition was designed to differentiate a practitioner's kMMT ability from his ability to "read" a patient.

There is also a further point to be considered. Critics of kMMT have suggested that practitioners may bias the test toward their preferred outcome, or what they think the outcome of the test ought to be. As an active kMMT practitioner myself, I acknowledge that it may be possible to influence the outcome of kMMT. I also acknowledge the possibility that patients may influence the outcome of kMMT, for example, through insincerity of effort.[98] However, little is currently known about the degree of influence that practitioners and patients may actually introduce into a muscle test. A final aim of this study was to investigate if it is possible to sway practitioner bias. Therefore, a different condition was presented to participants, unbeknownst to them, during the final part of testing, whereby it was attempted to mislead practitioners to see if their kMMT accuracies were affected. While this condition did not assess the amount of bias a test patient may contribute, it helped to ascertain if practitioner bias is a factor that needs further consideration.

To summarise, the primary aim of this study was to estimate the accuracy of kMMT for detecting lies in verbal statements spoken by a test patient when the muscle testing practitioner was blind to the verity of the spoken statement. Secondary aims were (1) to

detect factors that may influence kMMT accuracy, and (2) to estimate the amount of bias that may be introduced by the Practitioner and/or Test Patient (see Table 2.1).

TABLE 2.1 – Summary of study aims.

Primary	• To estimate the accuracy of kMMT to detect lies
Secondary	• To detect factors that may influence kMMT accuracy • To estimate the amount of bias that may be introduced by the Practitioner and/or TP

kMMT, kinesiology-style Manual Muscle Testing

Certainly, the primary purpose of this study was clear, which lent itself to a straightforward study design. However, the secondary aims added complexity to the methods, which warrant detailed description.

2.3 Methods

This study was a prospective study of diagnostic test accuracy. No participant was assessed prior to enrolment. This protocol received ethics committee approval in the United Kingdom (UK) by the Oxford Tropical Research Ethics Committee (OxTREC; Approval #34-09), and in America by the Parker University Institutional Review Board for Human Subjects (Approval #R09-09). Also, this study protocol was registered with two clinical trials registries: the Australian New Zealand Clinical Trials Registry (ANZCTR; www.anzctr.org.au), and US-based ClinicalTrials.gov. Written informed consent was obtained from all participants, and all other tenets of the Declaration of Helsinki were upheld. Finally, this paper was written in accordance with the Standards for the Reporting of Diagnostic Test Accuracy Studies (STARD) guidelines (see Appendix D, page 370, for the STARD Checklist).[47, 66, 99]

The methods presented here in this section formed the general structure for the subsequent studies in this series, and as a result, will be outlined in explicit detail. In later studies, depending upon the study objectives, some features were removed, in others, elements were changed; however, the fundamental study design remained consistent.

2.3.1 Participants and Setting

Two groups of participants were recruited: (1) Healthcare practitioners (n=48) who routinely use kMMT in practice ("Practitioners"), and (2) Test Patients (n=48) who were naïve to kMMT ("TPs"). Each Practitioner was paired with a single TP – and together they formed a unique testing pair ("Pair"; hence, n=48 unique pairs). Recruitment was by direct contact (via email or telephone), social media and word of mouth. Any volunteer was eligible if he or she was aged 18-65 years, had fully functioning and painfree upper extremities, and was fluent in English. Volunteers were excluded if they were visually-impaired, deaf or mute. All Practitioners who wished to participate and met the inclusion criteria were enrolled, regardless of their profession, kMMT technique(s) used, breadth of kMMT expertise or experience, or number of years in practice. Once a Practitioner was enrolled, a unique TP (unacquainted with the Practitioner) was then sought who met the enrolment criteria. See Table 2.2 for a summary of enrolment criteria.

TABLE 2.2 – Participant enrolment criteria.

Practitioner (n=48)	**Test Patient** (n=48)
• Aged 18-65 years • Fully functioning & painfree arms • Fluent in English • Not blind, deaf or mute • Did not know Test Patient • Any type of healthcare professional • Uses kMMT regularly in practice • Uses any kMMT technique(s) • Any amount of kMMT experience • Any amount of kMMT expertise • Any number of years in practice	• Aged 18-65 years • Fully functioning & painfree arms • Fluent in English • Not visually-impaired, deaf or mute • Did not know Practitioner • No prior experience with kMMT

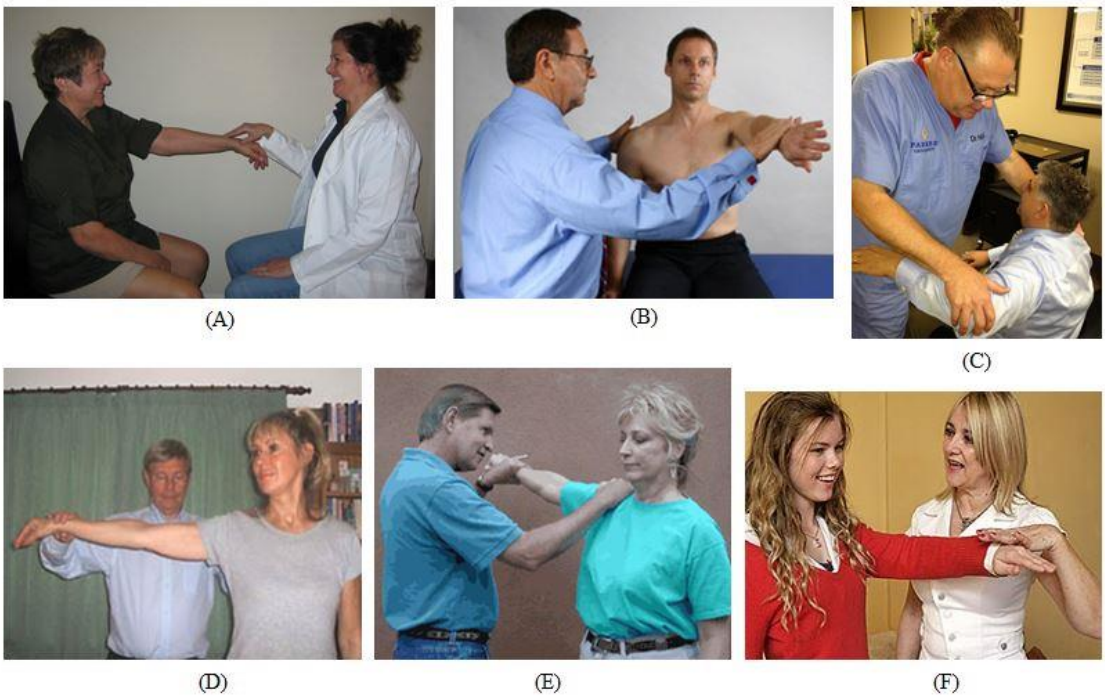
To simulate a real diagnostic environment, data were collected in private clinical settings whenever possible. All recruitment took place in the United Kingdom and in the US, in the states of Texas, Arizona, New Mexico and California. Once an eligible Practitioner was enrolled, a TP was sought and recruited from the lay public, and a mutually convenient time and place for testing was established. After arriving to the testing site, each participant was given a Participant Information Sheet (PIS) and gave written informed consent. Then they completed short Pre-Testing Questionnaires which collected demographic information and their views on kMMT (See Appendix A, page 245). They then were introduced to the testing equipment and started the Practice Phase, after which they began the actual testing phase of the study.

2.3.2 Practice Phase

After the initial forms were completed and prior to the commencement of testing both the Practitioner and the TP were given the opportunity to practise with the test equipment. Participants removed all watches and bracelets, and were individually instructed how to operate the equipment. Then they were allowed to practise until they felt they understood

what was expected of them and felt comfortable with the procedures. Next, the participants in each Pair were brought together for the first time. Then the Practitioner arranged the TP in his preferred kMMT position (see Figure 2.1 for examples of kMMT positions used in this study), and performed up to 5 practice tests in order to gauge the amount of force that would be required. Once both participants were comfortable with the equipment, the protocol, their positions and with each other, the testing phase was commenced.

FIGURE 2.1 – Examples of kMMT testing positions. (A) Both Practitioner and Test Patient seated, facing each other; (B) The Test Patient seated and the Practitioner standing to one side; (C) The Test Patient seated and Practitioner standing in front; (D) Both Test Patient and Practitioner standing, with the Practitioner behind; and (E) & (F) Both the Test Patient and the Practitioner standing, with the Practitioner in front to one side. Note also the variations of shoulder position, that in (B) the thumb of the Test Patient is down, and that in (C) the elbow of the Test Patient is bent.



2.3.3 Test Methods

In this section, I first describe in detail the target condition, the primary and secondary index tests, and the reference standard test. See Table 2.3 for a summary of study methods. Then I meticulously outline the testing procedure, and discuss the choice of stimuli, how blinding was accomplished, how results were recorded, and the statistical methods used for analysis.

2.3.3.1 The Target Condition

The target condition for which the Practitioners were testing was if the TPs were *lying*.[i] The presence (i.e. deceit) or absence (i.e. truth) of the target condition was strictly controlled: TPs were shown pictures on a computer screen, and were instructed (via an earpiece) to say a specific statement about the picture while viewing the picture on the computer screen. Sometimes the statement was false (i.e. target condition present) and sometimes it was true (i.e. target condition absent). For example, if a TP was presented with a picture of an apple and was instructed to say, "I see an apple," this statement was considered to be true. On the other hand, if a TP was presented with a picture of an apple and was instructed to say, "I see a horse," this statement was considered to be false, therefore, a lie. For an example of TP stimuli, click here.[ii] During the piloting of these methods, I monitored how explicitly TPs adhered to the instructions and was satisfied that adherence was excellent. Finally, it was presumed that TPs fully comprehended when they spoke true and false statements.

[i] Note that the words *lying* and *deceit* are used interchangeably.
[ii] http://youtu.be/itz0FgqWlss

TABLE 2.3 – Summary of general methods.

Target Condition …….. Truthfulness
Primary Index Test …… kMMT
Gold Reference Standard ..…… Verity of Spoken Statement
Secondary Index Test …… Intuition
Secondary Gold Standard …….. Verity of Spoken Statement

kMMT, kinesiology-style Manual Muscle Testing

2.3.3.2 The Primary Index Test: kMMT

Because of the many applications of kMMT and variations in kMMT techniques, a protocol for the index test was developed to maintain a degree of uniformity while at the same time, allowing Practitioners to remain true to their own clinical form: Practitioners were instructed to only use either the right or left anterior or lateral deltoid for testing while the TP was either seated or standing. Beyond that, Practitioners were permitted to individualise their testing methods, as long as the integrity of the study methods was maintained (e.g. blinding). Also, once a testing position was initiated, this position was retained for the duration of participation (i.e. they were not permitted to change arms or positions for the duration of the testing). For examples of various kMMT testing positions that pairs assumed, see Figure 2.1.

The paradigm used for these studies was: *A true statement results in a strong muscle test, and a false statement results in a weak muscle test.* Plus, since the target condition was *deceit*, and lying results in a "weak" muscle test, in the context of this study, a "weak" test was considered a "positive" result and a "strong" test was considered a "negative" result. While Practitioners were made fully aware of the paradigm to use during testing, TPs were kept uninformed. In other words, although TPs knew the study involved muscle

testing, they were not explicitly told: (1) that Practitioners were testing for deceit; (2) that their arms may go weak when they lied and stay strong when they told the truth; or (3) that a weak muscle test indicated a lie and a strong muscle test indicated a truth. Nor were TPs advised of the outcome of the test ("weak" or "strong') or the Practitioner's interpretation of the outcome. However, despite all attempts to keep TPs blind, it was suspected that some may guess the paradigm; therefore, this was monitored in the Post-Testing Questionnaire (See Appendix A, page 245).

Keeping in line with common clinical practice, the interpretation of the outcome of the kMMT was left to the discretion of each Practitioner. After performing a kMMT, the Practitioner alone decided if the muscle stayed strong or went weak, and recorded the results himself by entering "S" for "strong" or "W" for "weak" on a keyboard.

2.3.3.3 The Reference Standard: Actual Truth of the Spoken Statement

The reference standard used in this study was the actual truth of the spoken statement, which was always definitively known. Further, it was presumed that all participants knew the difference between True and False statements. Also, the true/false polarity of the statements were randomly presented, with approximately half being true and half being false, with each pair being presented with a different sequence.

2.3.3.4 The Secondary Index Test: Using Intuition to Distinguish Lies from Truth

As mentioned in the Introduction, there is a chance that it is not the kMMT itself that allows practitioners to differentiate lies from truths, but his capacity to "read" a patient. Therefore, to control for this possibility a second index test was enacted whereby the Practitioner was asked to use *intuition* (without muscle testing) if spoken statements were true or false. Taking into consideration the possibility of visual, auditory and kinesthetic

clues, Practitioners were asked to watch, listen, and touch the skin of their TP's arm as they spoke the given statements. Otherwise, the testing scenario remained exactly the same as during the kMMT, except kMMT was removed and Intuiting was implemented.

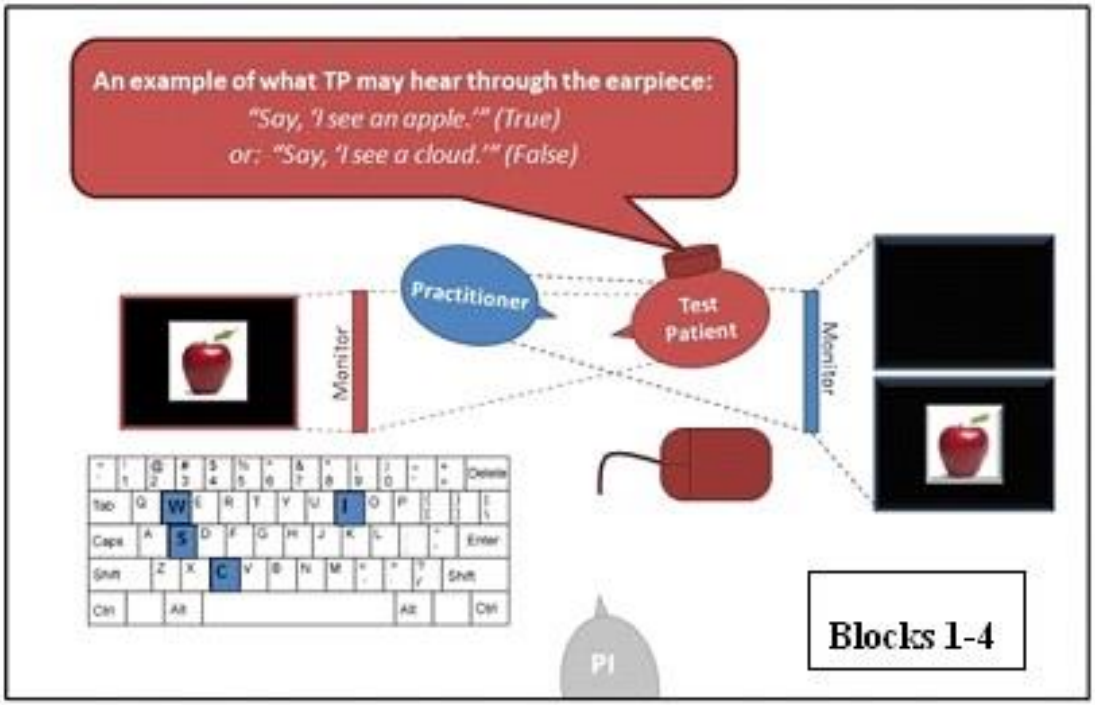
2.3.3.5 The Testing Scenario

Both the Practitioner and the TP viewed their own computer screens. The TP was presented with an affect-neutral picture and was instructed (via an earpiece) to say a specific statement while viewing the picture. For an example of a Pair performing a number of kMMTs, click here.[iii] In this video you can see the TP's screen and clearly see when her arm stays strong and goes weak.

In order to randomly blind the Practitioner to the verity of the spoken statement, he also viewed a computer screen which half the time presented the same picture as the TP's and half the time, a blank, black screen. See Figure 2.2 for a layout of the testing scenario. Moreover, on the participants' Instructions Sheets (see Appendix A, page 245), it was explicitly spelled out that the Practitioner's screen will be displaying either the same picture as the TP's or a blank, black screen. In the instance that the Practitioner was viewing a blank screen, he was blind to the verity of the TP's statement, and it was these blind tests only that were used to calculate the primary outcome (i.e. kMMT accuracy as overall fraction correct). The purpose of presenting to the Practitioner the ***same*** picture as the TP was three-fold: (1) it served to randomly blind the Practitioner, and to randomly blind the TP to the Practitioner's blindness; (2) it set up the ***Misled*** condition in Blocks 5 and 6 where I attempted to influence Practitioner bias (see below); and (3) it further served as a quality control, to see if Practitioners could be persuaded to bias the kMMT.

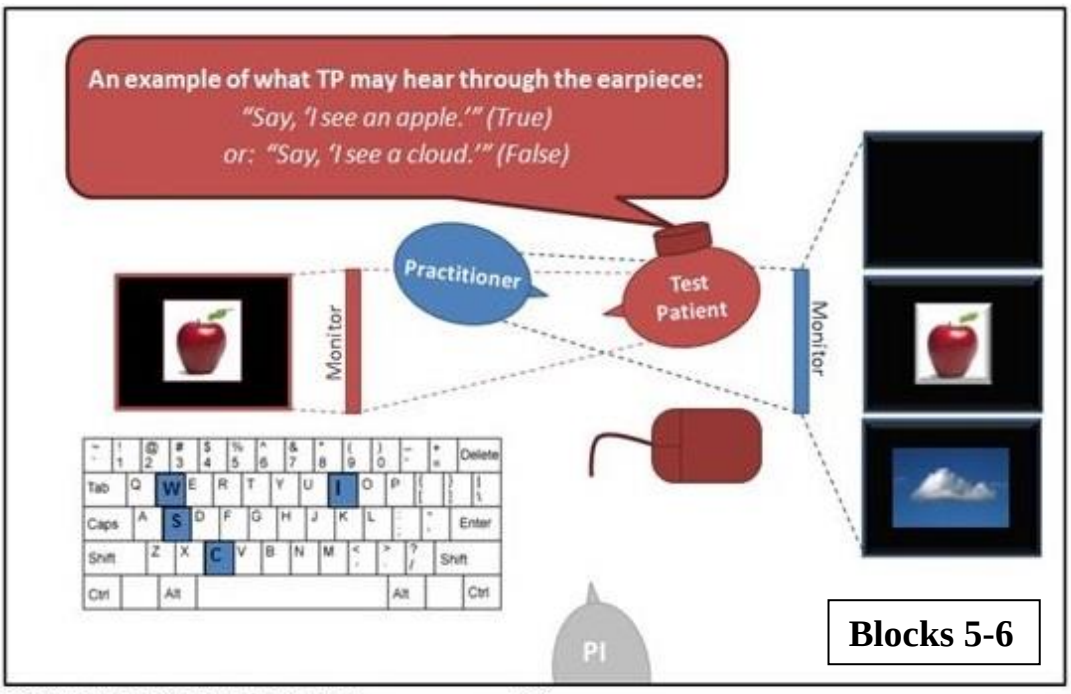
[iii] http://youtu.be/13w516uUNqA

FIGURE 2.2 - Testing scenario layout: (A) Blocks 1-4; (B) Blocks 5-6. The Practitioner (blue) viewed a monitor (also blue) which the Test Patient could not see and entered his results on a keyboard. The Test Patient (TP; red) viewed a monitor (also red) which the Practitioner could see, had an ear piece in his ear through which he received instructions, and used a mouse to advance his computer to the next picture/statement. Note that while in Blocks 1-4, the Practitioner was presented with either the *same* picture as the Test Patient or a blank, black screen, while in Blocks 5-6, a third possibility is introduced: a picture which was *different* from the Test Patient's picture. Also note that the Principal Investigator (PI) was present in the room and observing during all assessments.



TP, Test Patient; PI, Principal Investigator

(A)



TP, Test Patient; PI, Principal Investigator

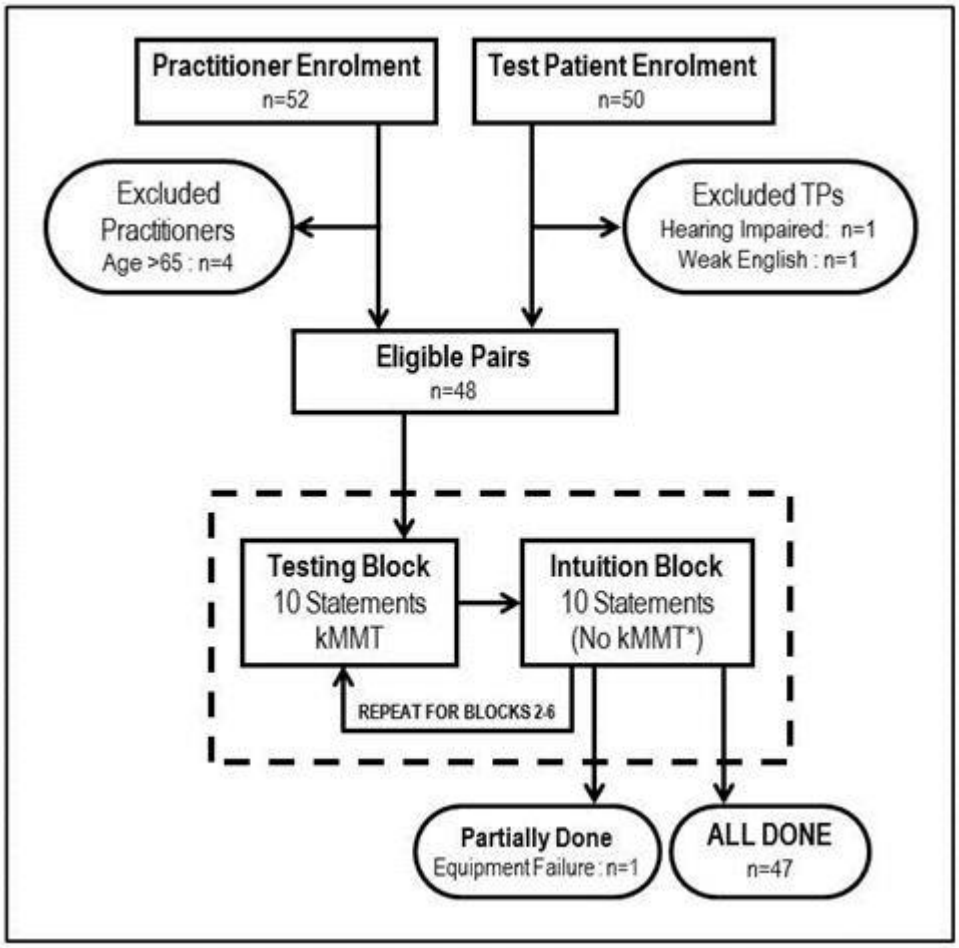
(B)

Each Practitioner performed 60 kMMTs on the TP, broken up into 6 blocks of 10 tests. In Blocks 1-4, each single test consisted of this sequence of events:

(1) the TP was presented with a picture on a computer screen and the Practitioner was presented with either the same picture or a blank, black screen,
(2) the TP was instructed (via an earpiece) to speak a specific statement while viewing the picture,
(3) the Pair assumed the testing position,
(4) the TP spoke the instructed statement while viewing the picture,
(5) the Practitioner performed the kMMT,
(6) the Practitioner entered the result of the kMMT into the computer ("S" for "strong" and "W" for "weak"), which advanced his monitor to the next picture,
(7) the TP pressed his left mouse button, which advanced his monitor to the next picture / instruction.

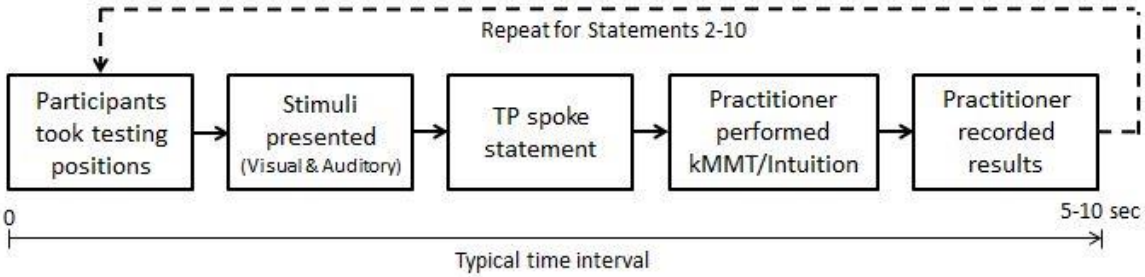
Then the sequence was repeated until 10 kMMT repetitions were completed (i.e. 1 kMMT Block). See Figure 2.3 for the Participant Flow Diagram, and Figure 2.4 for the flow of 1 test repetition.

FIGURE 2.3 – Participant Flow Diagram : Study 1



kMMT, kinesiology-style Manual Muscle Testing; TP, Test Patient; *Touching wrist & observing

FIGURE 2.4 – Flowchart for one kMMT / Intuition. Participant pairs performed 10 repetitions of this series per Block. kMMT Blocks were alternated with Intuition Blocks, and each pair performed 6 Blocks of each (kMMT & Intuition).



Blocks of Intuition alternated with blocks of kMMT. During the piloting of these methods, it was discovered that participants' arms fatigued from repeated kMMT; therefore, the addition of Intuition Blocks afforded a needed rest, as well as serving to control for Practitioner's ability to "read" their patients for clues of deceit.

The Intuition Blocks followed the same basic pattern as the kMMT Blocks:

(1) the TP was presented with a picture on a computer screen, and in Blocks 1-4, the Practitioner was presented with either the same picture or a blank, black screen,

(2) the TP was instructed (via an earpiece) to speak a specific statement while viewing the picture,

(3) the TP spoke the instructed statement while viewing the picture, as the Practitioner watched, listened and touched his arm,

(4) the Practitioner intuited silently to himself if the TP was telling the truth or lying,

(5) the Practitioner entered his response into the computer ("C" for *congruent*[iv] or truth and "I" for *incongruent* or lying), which advanced his monitor to the next picture,

(6) the TP pressed his left mouse button, which advanced his monitor to the next picture / instruction.

[iv] "I" stood for "incongruent" and "C" for "congruent." In the pilot, I used these terms to mean "lying" and "truth", respectively, so in subsequent studies, I kept the same format for convenience. In clinical practice, these terms are often used in this context: One is "congruent" with a concept one believes to be true, and "incongruent" with a concept that one believes to be untrue. [Walker, S.W., *Neuro Emotional Technique® Certification Manual*. 2004, Encinitas (CA): Neuro Emotional Technique, Inc.]

Then the sequence was repeated until 10 Intuition repetitions were completed (i.e. 1 Intuition Block). Again, see Figure 2.4 for the flow of 1 test repetition.

Six kMMT Blocks alternated with six Intuition Blocks, and each Pair started with a kMMT Block and ended with an Intuition Block. Unbeknownst to the participants, in Blocks 5 & 6, a twist was added to the testing scenario.

As mentioned, in Blocks 1-4 Practitioners were presented half of the time with the same picture as the TP's, and half of the time with a blank, black screen. However, in Blocks 5 & 6 for both kMMT and Intuition, 1/3 of the time he was shown the same picture, 1/3 of the time he was shown a blank, black screen and 1/3 of the time he was shown a picture ***different*** from the TP's. See Figure 2.2. Since participants were instructed that the Practitioner's screen will be showing either the same picture or a blank screen, the addition of the ***different*** picture was theoretically unanticipated, and so served to attempt to persuade the Practitioner to bias the kMMT.

While designing this study, much consideration went into the choice of 60 for the number of kMMT repetitions. First, I polled a number of muscle testing colleagues (n=6) and asked them to count the number of actual muscle tests they performed during one consultation (i.e. one office visit), and responses ranged from a low of 12 to a high of 80, with an average of 40 kMMTs/visit. So, I then experimented with the number of repetitions that could be feasibly done within a 20-minute period, and found that 40-60 kMMTs could be completed comfortably, and at approximately 60 kMMTs, patients started to show signs of fatigue. Therefore, I used 60 kMMT repetitions as a maximum per pair.

2.3.3.6 The Stimuli

The visual stimuli presented were pictures of common items and were selected from the International Affective Picture System (IAPS; National Institute of Mental Health Center for Emotion and Attention, University of Florida, Gainesville, FL).[100] Pictures with mean arousal levels between 4 and 7 (neutral to slightly positive valences) were chosen from the IAPS database,[100] and supplemented with additional similarly neutral pictures. The IAPS is a widely used, standardised testing system consisting of several thousand pictures of objects and images from everyday life.[100-103]

Likewise, the pictures were paired with words selected from the Affective Norms for English Words (ANEW; National Institute of Mental Health Center for Emotion and Attention, University of Florida, Gainesville, FL), which had a mean arousal valence between 4.74 and 7.57 (again, neutral to slightly positive valences).[104] The ANEW database is a list of verbal words with normative emotional ratings which complements the IAPS for a large number of words in the English language.[104, 105]

For this study, one hundred picture-word pairs were selected and placed into a database. Of these, 60 were randomly chosen to present to each pair in the kMMT Blocks, and 60 were randomly chosen to present to each pair in the Intuition Blocks. Stimuli were presented with a unique sequence of stimuli. The order of visual and audio stimuli was chosen and presented using DirectRT™ Research Software (Empirisoft Corporation, New York, NY). Since the choice of stimuli was randomly determined by the DirectRT Software, it was possible to have stimuli chosen twice – once during kMMT and once during Intuition; however, it was not possible for stimuli to be presented twice during kMMT or twice during Intuition. In other words, all 100 stimulus pairs were available to be chosen without replacement for each of the kMMT and Intuition conditions.

Furthermore, the valences of the statements (i.e. True or False) were also randomly selected by DirectRT software, as were the blinding of the Practitioner (i.e. Same Picture or Blank Screen in Blocks 1-4, or Same Picture or Blank Screen or Different Picture in Blocks 5 & 6). It is widely understood that the performance of a diagnostic test can change from one clinical setting to another due to the mix of patients and changes in prevalence, which may lead to spectrum bias.[106, 107] Therefore, since the actual usual prevalences that occur during a kMMT session are unknown, valence and blinding were randomly assigned settings,[106, 107] serving to mimic a normal spectrum. However, the participants were *not* informed of the exact proportions of True and False Statements or Blind or Not Blind cases, which might have introduced an expectation bias.[108] They were merely told there would be a mixture.

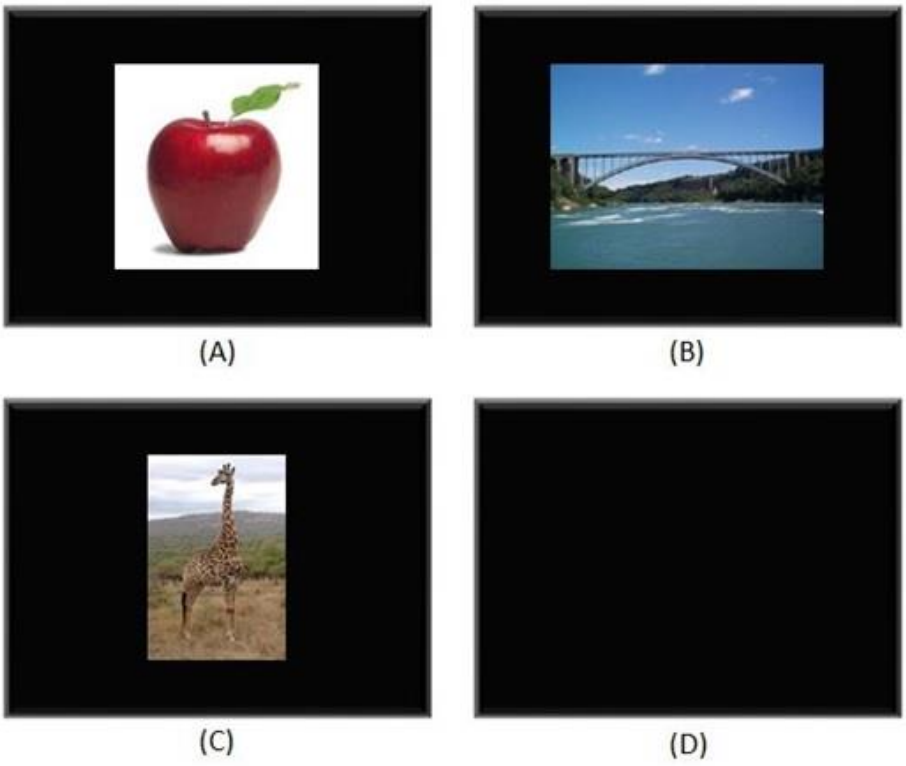
Since both the Practitioner and the TP were presented with visual stimulus on a computer monitor, participants and equipment were positioned in such a way as to ensure that each other's monitor was not visible by the other. Also, the auditory stimulus (i.e. the instruction what to say) was presented to the TP through a single earpiece, such that it was inaudible to the Practitioner. Finally, it was presumed that the participants recognised the picture being presented. For examples of the visual stimuli, see Figure 2.5. To hear examples of TP's auditory stimuli, click here[v] or here[vi] or here.[vii] To see examples of the paired stimuli that TPs might have been presented, click here.[viii]

[v] http://www.drannejensen.com/soundbites/apple.wav
[vi] http://www.drannejensen.com/soundbites/giraffe.wav
[vii] http://www.drannejensen.com/soundbites/bridge.wav
[viii] http://www.youtube.com/watch?v=itz0FgqWlss

2.3.4 Recording of Results

Once the Practitioner performed the kMMT and decided if the muscle stayed “strong” or went “weak,” he recorded his finding using a computer keyboard. In all cases, the Practitioner alone decided the outcome of the kMMT (i.e. “strong” or “weak”). He pressed the “S” key if the muscle stayed “strong” and the “W” key if the muscle went “weak.” In the case of Intuition, once the Practitioner decided if the TP was lying or telling the truth, he pressed the “I” key for lying and the “C” key for truth. This action advanced his computer monitor to the next picture. The outcome of the kMMT was not divulged to the TP. In addition, during piloting, I assessed if TPs were aware of the outcome of the kMMT was and if he noticed what the Practitioner was entering on the keyboard, and I was convinced that in both instances, the TPs were not aware of any test outcomes.

FIGURE 2.5 – Examples of visual stimuli. (A), (B) and (C) are examples that could have been presented to either the Test Patient or the Practitioner, while (D) – a blank, black screen – could have been presented only to the Practitioner.



2.3.5 Blinding

Since it was an aim of this study to investigate the impact that blinding had on kMMT accuracy, much thought was given about how to blind participants, both TPs and Practitioners.

Firstly, since TPs were kMMT-naïve, they were unaware of what kMMT involved and were unfamiliar with any kMMT paradigms. Also, while it was impossible to blind TPs to the reaction of their arms, they were not explicitly told when their arm stayed strong or went weak, and in many instances, the Practitioner's determination of test outcome ("strong" or "weak") was not obvious to me, an observer, during testing. In addition, because Practitioners were randomly blinded, TPs were effectively blind to the Practitioner's blindness. Furthermore TPs were blind to the interpretation of the kMMT outcome,[ix] and blind to what the Practitioner entered into the computer (e.g. "S" or "W"). Furthermore, no findings or results were discussed with the TP during the testing, nor was the TP's opinion sought. Finally, TPs were theoretically not blind to the verities of the statements they spoke. That is, it was presumed that TPs were aware of when they spoke true statements and when they spoke false statements.

On the other hand, blinding the Practitioner was, in many respects, more straightforward. To begin with, clearly Practitioners were ***not*** blind to the paradigm being used.[ix] They were also aware of: (1) the primary aim of the study (i.e. to estimate kMMT accuracy in detecting deceit); (2) that TPs were naïve to kMMT; (3) that TPs were unaware of the paradigm being used[ix]; and (4) TPs were going to be instructed to either lie or tell the truth. They were, however, randomly intermittently blind to the verity of the spoken

[ix] "Weak" was interpreted as "lying" and "Strong" was interpreted as "truth."

statement. In addition, in Blocks 5 & 6 when they were misled about the sameness of the picture they were shown, they were also blind to being blind. Taking all these factors into consideration, I believe that overall a high level of participant blinding was achieved.

2.3.6 Pre- and Post-testing Questionnaires

Participants were asked to complete two short questionnaires, one before testing started and one after testing was completed. The actual questionnaires can be found in Appendix A (page 245). In the Pre-testing Questionnaire, participants were asked questions about age, gender, handedness, kMMT experience, degrees of confidence, etc. These confidence questions were included because it is a popular, yet unsubstantiated, belief that practitioner confidence is associated with muscle testing accuracy. The degrees of confidence were measured using a 10cm Visual Analogue Scale (VAS) with the left end marked "None" and the right end marked with "Complete Confidence." The participants were asked to use a "|" to mark the VAS, which was subsequently assigned a score out of 10 rounded to the nearest 0.1cm. For example, if the participant drew his mark at 8.1cm along the line, he was given a score of 8.1 for that item. Lengths of time, such as ages and years in practice, were kept as continuous variables, while other variables, such as gender, profession, and kMMT techniques used, were kept as categorical variables.

In the Post-testing Questionnaire, participants were again asked about their degrees of confidence. In addition, in the Post-testing Questionnaire, TPs were asked to make open-ended comments about anything they noticed during the kMMT, in order to establish if they guessed the paradigm under investigation (i.e. hypothesis-guessing), so that response bias can be measured.[109, 110]

2.3.7 Pilot study

The methods described above were developed after considerable informal and then formal piloting, wherein flaws and difficulties were detected and remedied, sources of bias reduced and confounders, considered. For instance, I conducted a pilot study (n=12) with methods similar to this study; however, there were a number of differences. Firstly, practitioners with and without kMMT training were enrolled, and likewise, included were TPs who were kMMT-naïve and also those who were not naïve. Secondly, in a number of instances, the Practitioner and the TP knew each other. Thirdly, the pictures that the Practitioners were randomly shown could have been: (1) the same picture as the TP, (2) a blank, black screen, or (3) a picture different to the TP (i.e. the *Misled* condition, similar to Blocks 5 & 6). Finally, while the number of kMMTs was the same (60 repetitions), in the pilot there were no Intuition Blocks: Practitioners performed 60 kMMTs broken up into 6 Blocks of 10 kMMTs, with simply a 1-minute rest in between each Block. Aside from these variations, the methodologies were identical.

Twelve Practitioner-TP pairs participated in the pilot. Practitioners trained in kMMT were found to be 67.7% accurate (95% CI 52.6% to 82.8%), while those untrained were 51.7% accurate (95% CI 46.7% to 56.7%). See Table 2.4 for more pilot results.

TABLE 2.4 – Results of the pilot study. Comparison of Practitioner characteristics, **t**rained and untrained in kMMT.

	All Practitioners (n=12)	**Trained** (n=8)	**Untrained** (n=4)
Mean # Years in Practice (SD)	20.4 (10.0)	20.9 (11.2)	19.4 (8.6)
Mean # Years kMMT Experience (SD)		14.9 (7.3)	
Range of kMMT Experience (years)		7.6 – 30.0	
Self-Ranked kMMT Expertise* (SD)		3.6 (0.5)	
Mean Age (years) (SD)	51.3 (6.6)	52.5 (7.1)	48.8 (5.3)
Gender (Male:Female)	10:2	6:2	4:0
Practitioners by Profession:			
Chiropractors	9	5	4
Mental Health Professionals	2	2	0
Acupuncturists	1	1	0
Mean kMMT Accuracy†	0.624	0.677	0.517
95% Confidence Interval	0.526 - 0.722	0.526 – 0.828	0.467 – 0.567

kMMT, kinesiology-style Manual Muscle Testing; SD, Standard Deviation; * 0=No Expertise to 4=Expert; †Overall Fraction Correct

After completing this pilot, I made several distinct changes to the protocol that significantly strengthened this current study: (1) because the accuracy scores of Practitioners not trained in kMMT were similar to Chance (0.500), I decided to only recruit Practitioners explicitly trained in some form of kMMT; (2) to control the possibility of TP bias, it was decided to only recruit kMMT-naïve TPs; and most notably, (3) Intuition Blocks were added, alternating with kMMT Blocks, which made it possible to account for Practitioners perceiving any physiological clues of deceit, while at the same time allowing the Pairs to rest between kMMT blocks. Finally, performing this pilot study allowed me to use its results to perform a sample size estimation for this study.

2.3.8 Statistical Methods

Since the evaluation of the validity of kMMT is in its early stages, and since I am mainly interested in estimating how well kMMT is at detecting lies, I report error-based measures of accuracy: overall fraction correct, sensitivity, specificity, positive predictive

value (PPV) and negative predictive value (NPV) – with 95% confidence intervals (95% CI). Sensitivity can be described as the nonerror rate of those with the target condition.[73, 111] In this study, since the target condition is *deceit*, sensitivity was the proportion of false statements correctly identified as false. Specificity can be considered the nonerror rate of those without the target condition,[73, 111] so was calculated by finding the proportion of true statements correctly identified as true. Furthermore, PPV and NPV were the probabilities that a weak test result was actually a lie, and a strong test result was actually a truth, respectively. Since sensitivity and specificity can vary depending upon testing conditions,[73] and since little is known about the impact of false positives (FP) and false negatives (FN) in kMMT, I am taking FP to be equal in importance to FN, which later research might find inappropriate. Error-based measures were also reported for the Intuition condition. See Table 2.5 for a summary of the statistical terms.

Using the pilot data, a sample size for this full-scale study was calculated. I consulted with a statistician colleague, and after discussion, I decided that I wanted this study to be powered to 80%. Using the pilot data, I calculated the overall fraction correct for each pair, and then compared the mean to the proportion which would be expected by Chance alone (i.e. 0.500). Based on these assumptions and using a 95% confidence interval, I determined that a study of 48 pairs would have good statistical power to demonstrate whether trained practitioners can use kMMT to distinguish a lie from a truth. Statistical advice was sought during the design phase, after piloting, and before data analysis. All data were analyzed using Stata/IC 12.1 (StataCorp LP, College Station, Texas), specifically the commands "*ttest*" and "*pwcorr*."

TABLE 2.5 – Summary of statistical terms of the error-based measures of accuracy as defined in the context of this study.

Statistical Term	Definition within the context of kMMT
accuracy	The overall percent correct: (TP + TN) / (TP + FP + TN + FN).
sensitivity	The proportion of the Lies that were detected.
specificity	The proportion of the Truths that were detected.
positive predictive value (PPV)	The chance that if kMMT went weak that the statement was a Lie.
negative predictive value (NPV)	The chance that if kMMT stayed strong that the statement was True.

2.4 Results

2.4.1 Participants

Forty-eight unique Practitioner-TP Pairs were enrolled between June 2010 and October 2011. Four volunteer Practitioners were excluded because they did not meet the age criteria (i.e. they were aged > 65 years), and 2 volunteer TPs were excluded, one lacked fluency in English and the other was markedly hearing impaired. Of the 48 enrolled Pairs, there were 32 female and 16 male Practitioners, and 31 female and 17 male TPs. The mean (Standard Deviation, SD) age for Practitioners was 49.3 (12.0) years, and for TPs, 40.8 (12.8) years. Of the 48 Practitioners, 20 were chiropractors, 4 mental health professionals, 2 acupuncturists, 2 naturopaths, 2 massage therapists, 12 other health professionals, 4 non-health-professionals, and 2 did not respond to this question. Twenty-six Practitioners were in full-time practice, 13 were in part-time practice, 7 were not currently practising, and 2 did not respond to this question. The Practitioners' mean (SD) number of years in practice[x] was 14.8 (10.4), the mean (SD) years of kMMT experience[x]

[x] Two participants did not respond to this question.

was 12.9 (1.7), and the mean (SD) hours of performing kMMT/day[x] was 3.2 (0.6). Practitioners were also asked to rate their own kMMT expertise using a Likert scale from 0 (None) to 4 (Expert). The mean (SD) self-ranked kMMT Expertise[x] was found to be 3.1 (0.2), which suggests that the enrolled Practitioners considered themselves considerably proficient in kMMT. For a summary of Practitioner demographics, see Table 2.6.

TABLE 2.6 – Demographics of Practitioners.

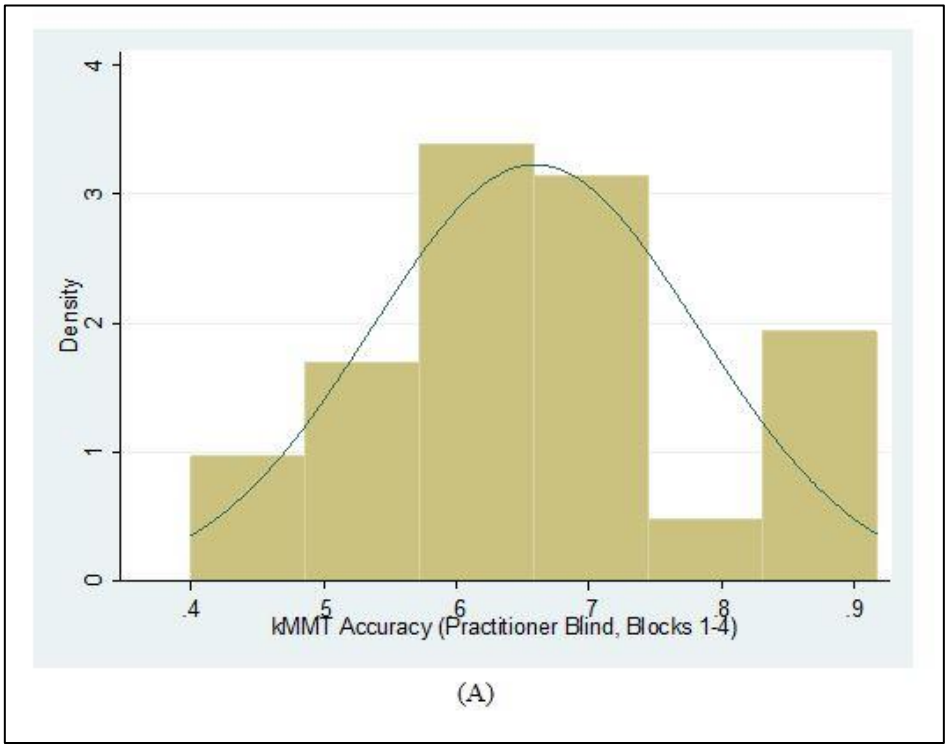
	Practitioners (n=48)
Gender (M:F)	16:32
Mean age[§] (SD)	48.5 (10.9)
Mean number of years in practice[§] (SD)	14.8 (10.4)
Mean years of kMMT experience[§] (SD)	12.9 (1.7)
Mean hours of kMMT/day[§] (SD)	3.2 (0.6)
Mean self-ranked kMMT Expertise*[§] (SD)	3.1 (0.2)
Mean degree of confidence in own kMMT ability (before testing)†[§] (SD)	8.7 (0.2)
Mean degree of confidence in kMMT in general (before testing)†[§] (SD)	8.8 (0.3)
Profession (n)	
Chiropractor	20
Mental Health Professional	4
Acupuncturist	2
Naturopath	2
Massage Therapist	2
Other Health Professional	12
Other Professional	4
Did not respond	2
Current Practice Status (n)	
Full-time	26
Part-time	13
Not practising	7
Did not respond	2
Type(s) of kMMT Technique(s) used: (n)	
Neuro Emotional Technique (NET)	22
Applied Kinesiology (AK)	17
Total Body Modification (TBM)	6
BodyTalk	4
Health Kinesiology (HK)	4
Touch for Health	4
Contact Reflex Analysis (CRA)	3
PSYCH-K	3
Clinical Kinesiology (CK)	2
Kinesionics	2
Nutritional Response Testing (NRT)	2
Other‡	13
Did not respond	2

kMMT, kinesiology-style Manual Muscle Testing; SD, Standard Deviation;
* Self-ranked kMMT Expertise, ranged from 0=None to 4=Expert
** Test Anxiety refers to the amount of anxiety the Practitioner was expereincing just prior to testing
§ Some Practitioners (n) did not respond to this question: Age (2), Years in Practice (2), Years of kMMT experience (2), Hours of kMMT/day (6), Self-ranked kMMT Expertise (2), Confidence in own kMMT (2), Confidence in kMMT in general (2).
†Measured using a Visual Analog Scale, from 0="None" to 10="Most Ever"
‡ Other kMMT techniques included 1 Practitioner each: Be Set Free Fast (BSFF), Belief System Technique, BioKinesiology, Energy Kinesiology, GeoTran Integrations, Lifeworks, Nambudripad's Allergy Elimination Techniques (NAET), Neural Organization Technique (NOT), Sacro Occiptial Technique (SOT), Soft Tissue Orthopedics (STO), Thought Field Therapy (TFT), Wellness Kinesiology, Wholistic Kinesiology.

2.4.2 Test Results

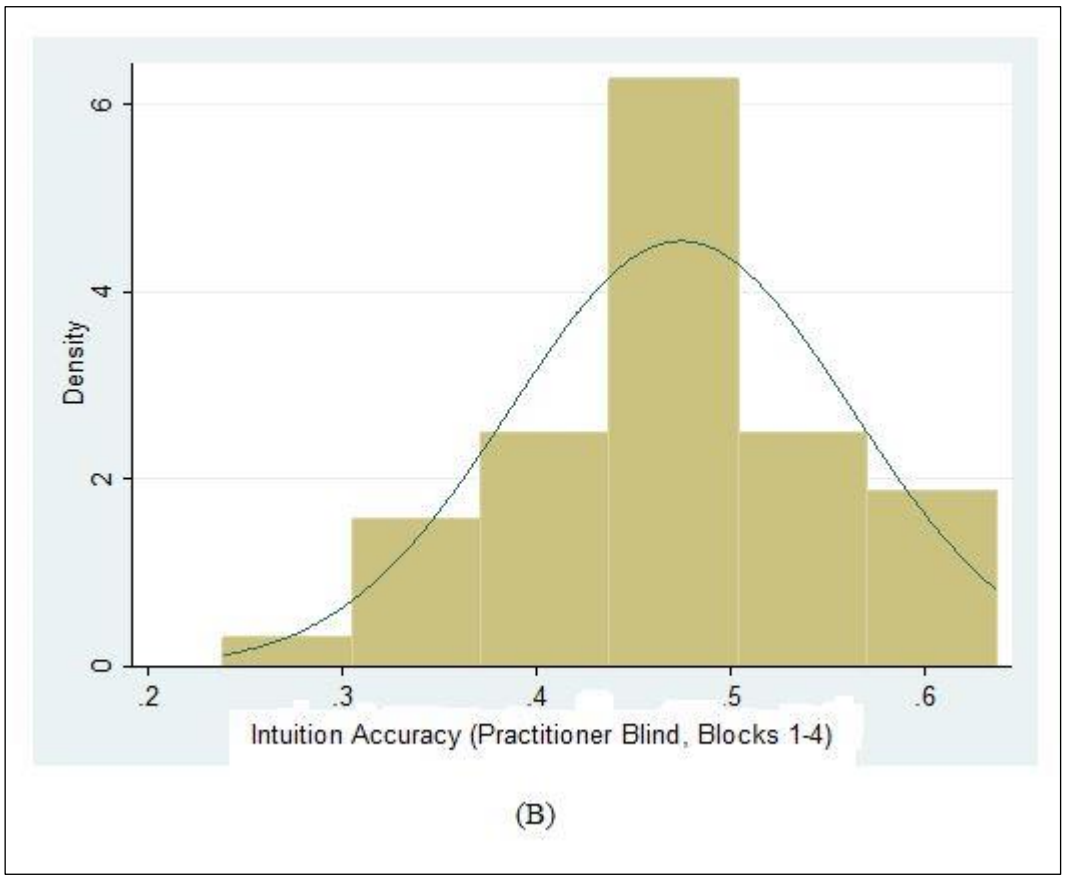
Pairs took between 20 minutes and 1 hour to complete their participation. Of the 48 Pairs, 47 completed the muscle testing assessment in full, while 1 Pair completed only Blocks 1-4, due to a technical problem with the testing equipment. In this results section, for simplicity's sake and for clarity, the term "kMMT accuracy" means "the overall fraction correct[xi] while the Practitioner was blind, in Blocks 1-4 only", unless otherwise stated. Histograms of all accuracy scores show that the data are normally distributed (see Figure 2.6 and Appendix Figure B.2.1), so parametric statistics have been applied below.

FIGURE 2.6 – Histogram showing Normal Distributions of accuracies – indicating use of t-test statistic is appropriate (n=48). (A) kMMT (40 tests), while Practitioner was Blind (Blocks 1-4 only), (B) Intuition (40 Intuits), while Practitioner was Blind (Blocks 1-4 only).



[xi] Accuracy = Overall Fraction Correct = (TP+TN)/ (TP+FP+TN+FN) [TP=True Positives; TN= True Negatives; FP=False Positives; FN=False Negatives]

FIGURE 2.6 (con't.)



2.4.2.1 Accuracies: Blocks 1-4

Diagnostic accuracy can be expressing using a number of statistics: Overall fraction correct, sensitivity, specificity, PPV and NPV. The kMMT 2x2 tables for each Pair are located in Appendix Table B.2.1. Since the valence of the statements (i.e. True or False) and the blinding of the Practitioners were both randomly allocated for each Pair, their prevalences varied from Pair to Pair. This random allocation caused a variation in the prevalence of the target condition (i.e. Lies, or False Statements). The prevalence of Lies ranged from 0.25 to 0.67, and was normally distributed (see Appendix Figure B.2.1.A) with a mean of 0.47, and a 95% Confidence Interval (CI) of 0.45 – 0.50.

The primary outcome, kMMT overall fraction correct, was estimated by computing the individual accuracies of the Pairs. Similar computations were done to estimate overall sensitivity, specificity, PPV and NPV. The mean (95% CI) accuracy for

kMMT while the Practitioner was blind was 0.659 (0.623 - 0.695), and a range of 0.400 - 0.917. The mean (95% CI) accuracy for Intuition was 0.481 (0.456 - 0.506), and with a range of 0.238 - 0.636. Since these data were normally distributed (see Figure 2.6), a Student t-test was used to calculate significance. Under these conditions, when the mean accuracy of kMMT was compared to the mean accuracy of Intuition, a significant difference was found ($p<0.01$; see Table 2.7). Likewise, when the mean accuracy of kMMT was compared to the likelihood of Chance[xii] (0.500), significance was also reached ($p<0.01$), as was the mean accuracy of Intuition compared to Chance ($p<0.05$). In addition, visual inspection of a scatterplot of kMMT Accuracy vs. Intuition Accuracy (see Figure 2.7) suggested that there was no correlation between the two ($r = 0.057$).

The mean (95% CI) sensitivity for kMMT was 0.568 (0.504 - 0.633) and the mean (95% CI) specificity for kMMT was 0.734 (0.687 - 0.782), while the mean (95% CI) PPV for kMMT was 0.663 (0.607 - 0.781) and the mean (95% CI) NPV for kMMT was 0.667 (0.625 - 0.708). See Table 2.7. A receiver operator characteristic (ROC) space (see Figure 2.8) shows that all but 7 pairs performed better than Chance.[112]

[xii] Chance here refers to the hypothetical situation where either outcome was equally likely: 50-50.

TABLE 2.7 – Diagnostic Accuracy while Practitioner is Blind (Blocks 1-4): The means and 95% CIs for Overall Fraction Correct, Sensitivity, Specificity, Positive Predictive Value, and Negative Predictive Value. (A) For kMMT; (B) For Intuition.

	(A) kMMT			(B) Intuition		
	n	**Mean**	**95% CI**	***n***	**Mean**	**95% CI**
Overall Fraction Correct	48	0.659	0.623 - 0.695	48	0.481	0.456 - 0.506
Sensitivity	48	0.568	0.504 - 0.633	48	0.392	0.334 - 0.450
Specificity	48	0.734	0.687 - 0.782	48	0.542	0.480 - 0.603
Positive Predictive Value	47	0.663	0.607 - 0.781	47	0.458	0.405 - 0.511
Negative Predictive Value	48	0.667	0.625 - 0.708	47	0.469	0.421 - 0.518

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval

FIGURE 2.7 – Scatterplot of kMMT Accuracy vs. Intuition Accuracy – when the Practitioner is Blind (Block 1-4 only).

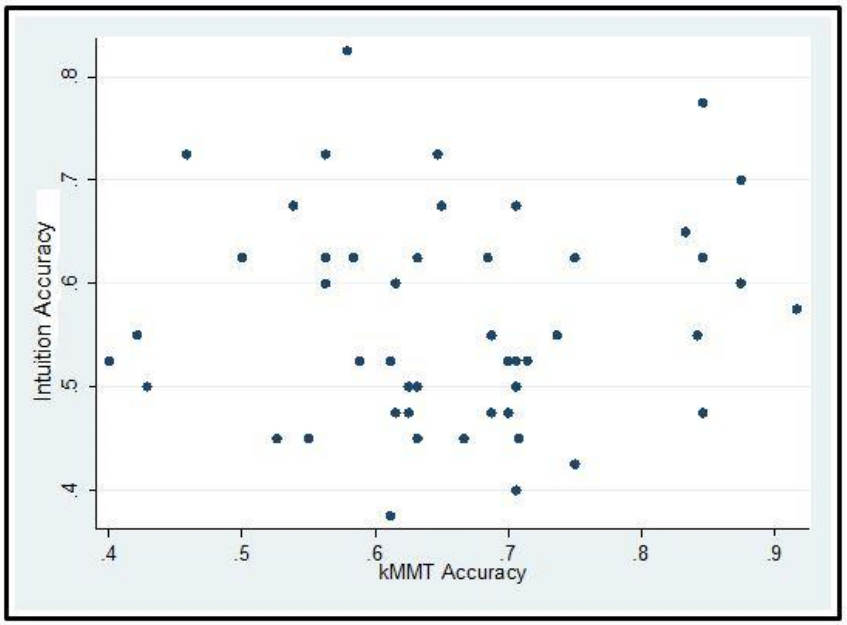
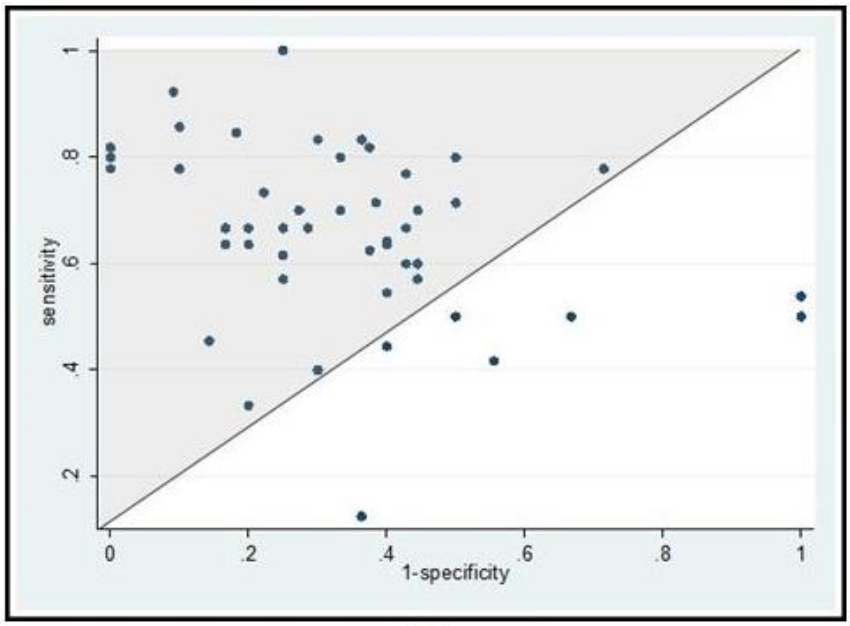
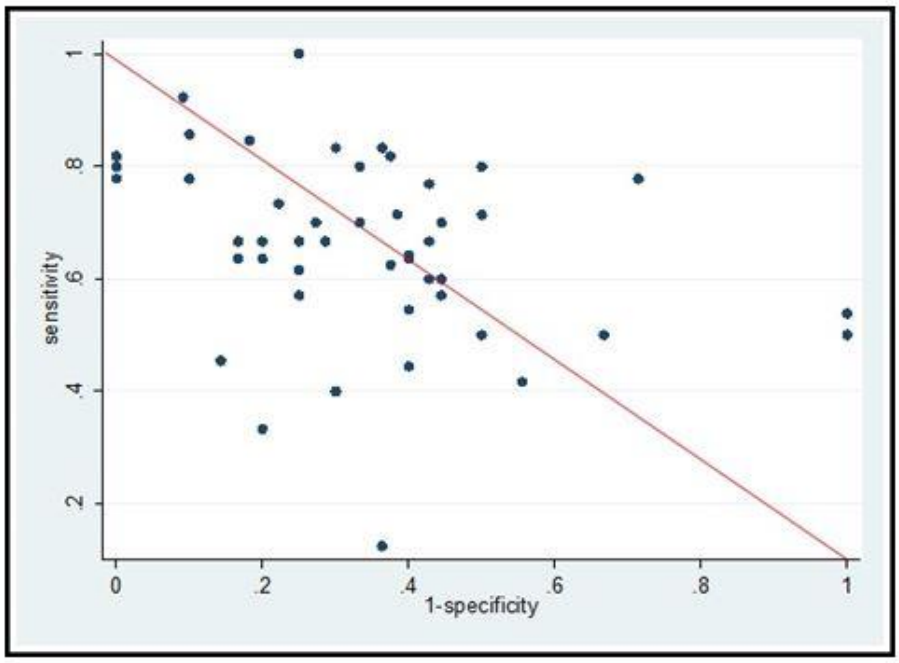


FIGURE 2.8 – ROC Spaces and ROC Curve for kMMT. (A) Shadow area represents better performances; (B) Those above the red diagonal had a tendency toward finding strong kMMT responses, while those below the red diagonal had a tendency toward weak kMMT responses; (C) ROC Curve. [In Blocks 1-4 only, when the Practitioner was Blind (n=48 pairs).]

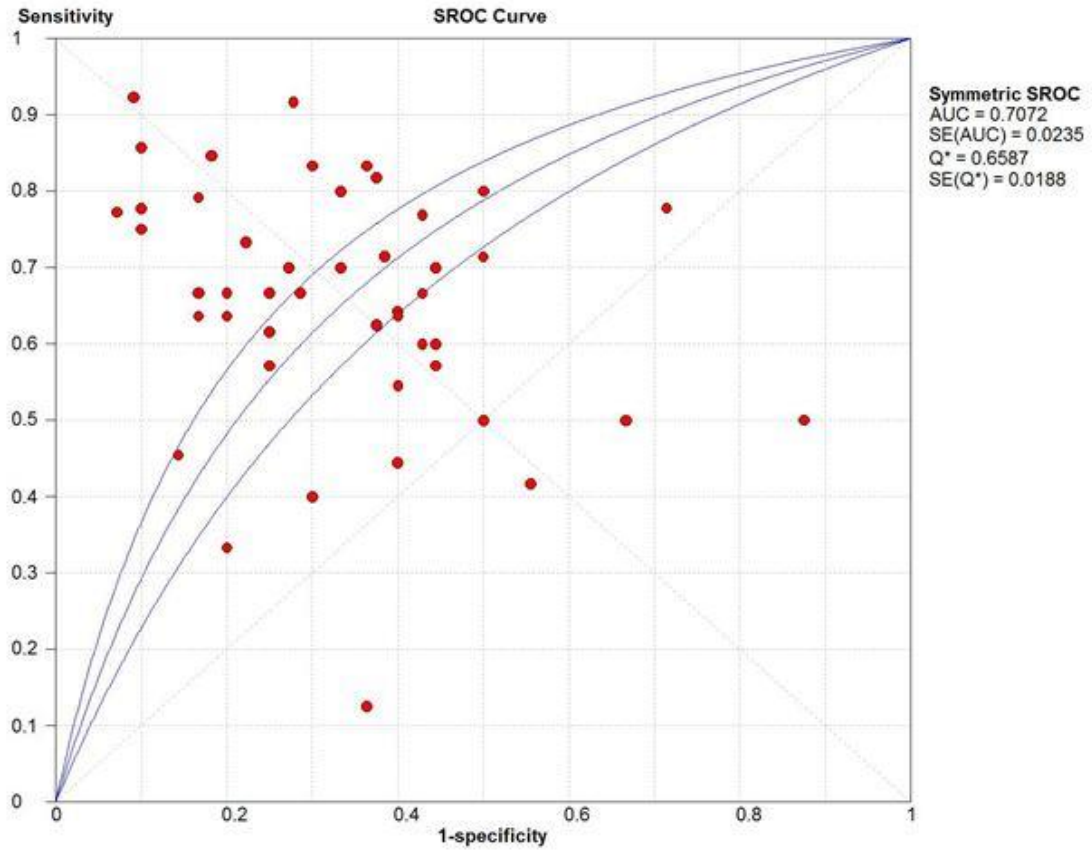


(A)

FIGURE 2.8 (con't.)



(B)



(C)

The condition in Blocks 1-4 where the Practitioner was shown the ***same*** picture as the TP was introduced primarily for quality control. Therefore, in those instances where the Practitioner was *not* blind but actually knew the verity of the TP's spoken statement, both the kMMT and Intuition accuracies theoretically should have been a perfect 1.000. However, this was not the case: The mean (95% CI) accuracy for kMMT was 0.639 (0.585 - 0.693), and for Intuition, 0.631 (0.577 - 0.685). While they were both significantly different from Chance[xii] (p<0.01 for both), they were not distinctly different from each other (p=0.73). Furthermore, when comparing the Not Blind kMMT accuracy to the Blind kMMT accuracy, no significant difference was found between the scores (p= 0.44), and they were significantly correlated (r = 0.383, p=0.01).

As a check, I also compared the kMMT and Intuition accuracies of False Statements and True Statements separately, which theoretically should have been the same as sensitivity and specificity, respectively. Fortunately, they were. See Appendix Table B.2.2. Also, comparing kMMT Accuracies for True vs. False Statements showed no correlation using both a visual inspection of its scatterplot (see Appendix Figure B.2.2.Q), and the calculation of a correlation coefficient (r = -0.1761, p<0.05).

2.4.2.2 Accuracies: Blocks 5 & 6

In the last 2 Blocks, when the Practitioners were intermittently Misled by randomly being shown pictures that were different from the TP's, mean (95% CI) accuracies for both kMMT and Intuition dropped slightly to 0.566 (0.494 - 0.638) and 0.418 (0.351 - 0.484) respectively, which were still significantly different from each other (p<0.01). See Table 2.8.A.

TABLE 2.8 – The Impact of Misleading the Practitioner on kMMT & Intuition Accuracies (for n=48 pairs). kMMT vs. Intuition Accuracies for the Misled Condition; Misled vs. Not Misled kMMT Accuracies for Blind and Not Blind Conditions.

(A)	MISLED		
	kMMT	**Intuition**	***p*-value**
Mean	0.566	0.418	**<0.01***
95% CI	0.494 - 0.638	0.351 - 0.484	
Minimum	0.000	0.000	
Maximum	1.000	1.000	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; *Significance reached

(B)	kMMT Accuracy					
	Misled	**Blind, Not Misled**	***p*-value**	**Misled**	**Not Blind Not Misled‡**	***p*-value**
Mean	0.566	0.659	**<0.01***	0.566	0.639	0.11
95% CI	0.494 - 0.638	0.623 - 0.695		0.494 - 0.638	0.585 - 0.693	
Minimum	0.000	0.400		0.000	0.304	
Maximum	1.000	0.917		1.000	1.000	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; *Significance reached
† Blind, Not Misled = In Blocks 1-4, Practitioer was shown a blank, black sceen
‡ Not Blind, Not Misled = In Blocks 1-4,Practitioner was shown the same picture as the Test Patient

Also, I compared the kMMT accuracies in the condition where the Practitioners were Misled (i.e. Blocks 5-6, shown a picture different from the TP) to the 2 conditions where (1) the Practitioners were Blind and Not Misled (i.e. Blocks 1-4, shown a blank, black screen), and (2) the Practitioners were Not Blind and Not Misled (i.e. Blocks 1-4, shown the same picture as the TP). The former comparison showed a significant decrease in kMMT scores ($p<0.01$) during the Misled condition, and the latter showed no significant difference ($p= 0.11$) between the two conditions. See Table 2.8.B.

2.4.2.3 Pre- & Post-testing Confidence Ratings

Before and after testing, participants were asked to rate their levels of confidence on a 10cm VAS. TPs ranked their levels of confidence they had in kMMT in general, in their Practitioner and in their Practitioner's kMMT ability. Similarly, pre- and post-testing,

Practitioners rated their levels of confidence they had in kMMT in general, in their own kMMT ability, and in their ability to kMMT their paired TP (post-testing only).

TPs'[x] Confidence ratings (95% CI) were:

(1) Confidence in kMMT in general (pre-testing): 6.76 (6.16 – 7.36);
(2) Confidence in kMMT in general (post-testing): 7.22 (6.63 – 7.81);
(3) Confidence in Practitioner (pre-testing): 6.95 (6.30 – 7.61);
(4) Confidence in Practitioner (post-testing): 7.63 (7.01 – 8.25);
(5) Confidence in Practitioner's kMMT ability (pre-testing): 7.00 (6.35 – 7.65); and
(6) Confidence in Practitioner's kMMT ability (post-testing): 7.76 (7.10 – 8.41).

The increase in TP Confidence in kMMT in general reached significance (p= 0.03), as did both the increase in TP Confidence in their Paired Practitioner (p= 0.01) and the increase in TP Confidence in Practitioner's kMMT ability (p= 0.01).

Practitioners[x] Confidence ratings (95% CI) were:

(1) Confidence in their own kMMT ability (pre-testing): 8.43 (8.02 – 8.85);
(2) Confidence in their own kMMT ability (post-testing): 8.15 (7.67 – 8.63);
(3) Confidence in kMMT in general (pre-testing): 8.67 (8.22 – 9.12);
(4) Confidence in their ability to kMMT their paired TP (post-testing): 8.42 (7.94 – 8.92); and
(5) Confidence in their own kMMT ability (post-testing): 7.79 (7.12 – 8.46).

Although the Practitioners ratings of Confidence in their own kMMT ability and Confidence in kMMT in general both dropped, their differences did not reach significance (p=0.20 and p=0.22, respectively).

2.4.2.4 Potential Influencers of Accuracies

It is thought that there are many factors that contribute to the accuracy of kMMT. Such factors include practitioner and/or patient bias, length and extent of practitioner experience, fatigue and dehydration, to name a few.

Looking to see if and how the TP influences the outcome, I compared the mean accuracies of those pairs whose TP reported guessing the paradigm (n=21) to those pairs whose TPs did not report guessing the paradigm (n=27). For those pairs whose TP reported guessing the paradigm (n=21), the mean accuracy of kMMT was 0.661 (95% CI 0.591-0.730), and for those pairs whose TP did not report guessing the paradigm (n=27), the mean accuracy of kMMT was 0.649 (95% CI 0.610-0.688). Since I hypothesised that those pairs whose TPs reported guessing the paradigm, might have a higher accuracy than the other group, I used a 1-sided t-test for two samples with unequal variances, and found that they was no significant difference between these two groups (p=0.38). See Table 2.9.A.1.

Also, because it was suggested to me that Practitioners may "cheat" during testing by seeing a reflection of the TP's screen in their eyeglasses, TP's eye-glass-wearing was tracked. The mean accuracy of pairs whose TPs wore glasses (n=15) was 0.640 (95% CI 0.592-0.687), and the mean accuracy of pairs whose TPs did *not* wear glasses (n=31) was 0.661 (95% CI 0.611-0.712). As such, there was no significant difference (p=0.26) in kMMT accuracies between these two groups. See Table 2.9.A.2.

I also tested to see if Practitioner profession, practising status or self-ranked kMMT expertise affected kMMT accuracy. The mean accuracy (95% CI) for the 20 chiropractors who participated was 0.670 (0.611 - 0.729), and for the 26 non-

chiropractors[x], 0.642 (0.593 - 0.691), whose difference did not reach significance (*p*=0.45). See Table 2.9.B.1, and the Appendix Table B.2.3. Likewise, the mean accuracy (95% CI) for those in full-time practice (n=26) was 0.663 (0.612 - 0.715), part-time practice (n=13), 0.682 (0.618 - 0.746), and not practising (n=7)[x] 0.569 (0.465 - 0.673). When the accuracies of all three groups were compared using an Analysis of Variance (ANOVA), no difference was found between the three groups (*p*=0.45). See Table

TABLE 2.9.A – The influence of various categorical factors of the Test Patient on kMMT accuracy. The Test Patient guessing the paradigm, and (2) The Test Patient wearing glasses during testing.

(A)	Mean kMMT Accuracies			
	(1) TP Reported Guessing the Paradigm?		(2) TP wore Glasses?†	
	Guessed the Paradigm (n=21)	Did NOT Guess the Paradigm (n=27)	Wore during testing (n=15)	Did NOT wear during testing (n=31)
Mean	0.661	0.649	0.640	0.661
95% CI	0.591 - 0.730	0.610 - 0.688	0.592 - 0.687	0.611 - 0.712
Minimum	0.400	0.421	0.500	0.400
Maximum	0.917	0.875	0.842	0.917
***p* -value**	0.38		0.26	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; TP, Test Patient; † Two participants did not respond to this question.

2.8.B.2. Similarly, the mean kMMT accuracy (95% CI) of those Practitioners who ranked themselves as "Expert" muscle testers (4/4; n=15) was 0.682 (0.617 - 0.747), of those who ranked themselves as 3 out of 4 (n=19), 0.666 (0.605 - 0.728), and of those who ranked themselves as 1 or 2 out of 4 (n=12)[xiii], 0.600 (0.528 - 0.672). While the kMMT accuracies steadily decreased with ranking, no significant differences were found between these 3 groups (*p*=0.35). See Table 2.9.B.3.

[xiii] Two Practitioners did not respond to this question, and none ranked themselves as a "0".

TABLE 2.9.B – The influence on various categorical characteristics of Practitioner on kMMT Accuracy. (1) Practitioner Profession, (2) Practitioner's Practising Status, and (3) Practitioner's Self-Ranked kMMT Expertise.*

(B)	kMMT Accuracy							
	(1) Practitioner Profession†		(2) Practitioner Practising Status†			(3) Self-ranked kMMT Experise (0-4)†		
	Chiropractors (n=20)	All others (n=26)	Full Time (n=26)	Part Time (n=13)	Not Practising (n=7)	4 (n=15)	3 (n=19)	1 or 2‡ (n=12)
Mean	0.670	0.642	0.663	0.682	0.569	0.682	0.666	0.600
95% CI	0.611 - 0.729	0.593 - 0.691	0.612 - 0.715	0.618 - 0.746	0.465 - 0.673	0.617 - 0.747	0.605 - 0.728	0.528 - 0.672
***p*-value**	0.45§		0.13§§			0.35§§		

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Two (2) participants did not respond to this question; § t-test result; §§ ANOVA result;
* Practitioners were asked to rank their own kMMT ability from 0 ("None") to 4 ("Expert"); ‡ Eleven Practitioners responded "2", one responded "1" and zero responded "0";

Since females seem to have an advantage over men in empathy and decoding nonverbal communication,[113, 114] participant gender may have had an impact on kMMT performance as well. Therefore, I compared the kMMT accuracies by the genders of the Practitioners and TPs, as well as the sameness of the genders of the Pairs. For male Practitioners (n=16), the mean accuracy (95% CI) was 0.665 (0.608 - 0.722), and for female Practitioners (n=32), it was 0.656 (0.609 - 0.704), which did not prove to be significantly different (p=0.81). However, using male TPs (n=17), the mean accuracy (95% CI) was 0.715 (0.653 - 0.778), and using female TPs (n=31), it was 0.628 (0.586 - 0.671), which ***was*** found to be significantly different (p=0.02). For those Practitioner-TP Pairs of the same gender (Male-Male or Female-Female; n=27 Pairs), the mean accuracy (95% CI) was 0.658 (0.603 - 0.713), and for different gender Pairs (Male-Female or Female-Male; n=21 Pairs), it was 0.661 (0.614 - 0.708), which also did not prove to be significantly different (p=0.92). See Table 2.9.C.

Choice of arms may also have influenced kMMT accuracy. Looking at the Practitioner's preferred arm (of their own) with which to perform kMMT, the kMMT accuracy (95% CI) of those Practitioners that preferred their right arm (n=35) was 0.650 (0.612 - 0.688), and of those that preferred their left arm (n=16) was 0.655 (0.583 - 0.726), which was not significantly different (p=0.90). Note that 5 Practitioners indicated that they prefer either arm, so were included in both groups, and 2 Practitioners did not respond to this question. Of those Pairs where the TP's dominant arm was tested (n=18), the mean kMMT accuracy (95% CI) was 0.678 (0.609 - 0.746), and whose non-dominant arm was tested (n=28), 0.639 (0.596 - 0.683), which also was not significantly different (p=0.33). See Table 2.9.D.

To see if kMMT accuracy differed by Block, I compared the mean kMMT accuracies for Blocks 1 through 4. Figure 2.9 shows a bar graph of mean kMMT accuracies (with 95% CIs) by Block, and no trend is obvious. Further exploration revealed no correlation among kMMT accuracy by Block (see Table 2.10).

TABLE 2.9.C – The influence on various mixed categorical variables on kMMT Accuracy. (1) Practitioner's Gender, (2) Test Patient's Gender, and (3) Sameness of Gender.

(C)	kMMT Accuracy					
	(1) Practitioner's Gender		(2) Test Patient's Gender		(3) Practitioner & TP Gender	
	Males (n=16)	**Females** (n=32)	**Males** (n=17)	**Females** (n=31)	**Same** (n=27)	**Different** (n=21)
Mean	0.665	0.656	0.715	0.628	0.658	0.661
95% CI	0.608-0.722	0.609-0.704	0.653-0.778	0.586-0.671	0.603-0.713	0.614-0.708
Minimum	0.538	0.400	0.500	0.400	0.400	0.500
Maximum	0.875	0.917	0.917	0.846	0.875	0.917
***p*-value**	0.81		**0.0216***		0.92	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; TP Test Patient; *Significance reached.

TABLE 2.9.D – The influence on various categorical variables on kMMT Accuracy. Choice of Practitioner's and Test Patient's arms.

(D)	kMMT Accuracy			
	Practitioner's Preferred Choice of Own Arm for kMMT†**		Test Patient's Arm Used†	
	Right (n=35)	**Left** (n=16)	**Dominant** (n=18)	**Non-Dominant** (n=28)
Mean	0.650	0.655	0.678	0.639
95% CI	0.612 - 0.688	0.583 - 0.726	0.609 - 0.746	0.596 - 0.683
Minimum	0.400	0.421	0.421	0.400
Maximum	0.875	0.917	0.917	0.846
***p*-value**	0.90		0.33	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Two (2) participants did not respond to this question; ** Five (5) Practitioners preferred either right or left.

FIGURE 2.9 – kMMT Accuracy by Block with 95% Confidence Intervals.

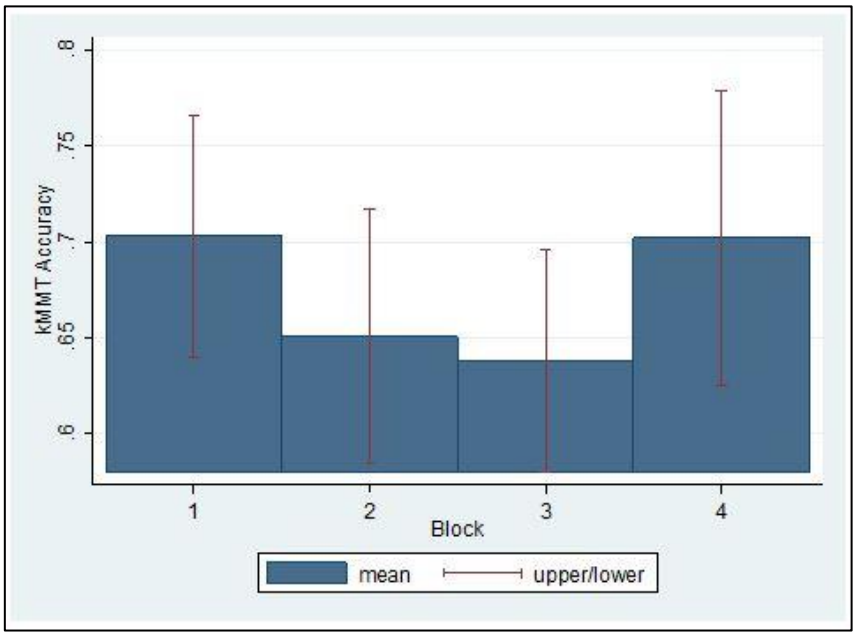


TABLE 2.10 – Correlations (r) among kMMT Accuracies by Block. With p-values (n=48).

	Block 1	Block 2	Block 3
Block 1	1.0000		
Block 2	-0.034	1.0000	
p-value	*0.82*		
Block 3	0.2589	0.1398	1.0000
p-values	*0.08*	*0.34*	
Block 4	0.2153	-0.0459	0.1179
p-values	*0.14*	*0.76*	*0.42*

kMMT, kinesiology-style Manual Muscle Testing.

2.4.2.5 Correlation Testing

In an effort to further understand the relationships between kMMT accuracy and other participant characteristics, correlation analyses were run, first by visually inspecting scatterplots (see Appendix Figure B.2.2), and then by creating correlation matrices using Stata's "*pwcorr*" command. Reviewing the scatterplots, no correlations were obvious, so further statistical analysis was performed. Calculating the correlation matrix using kMMT accuracy and the Practitioner characteristics of age, years in practice, years

practising kMMT, and average hours per day using kMMT, I found no relationship reached significance with kMMT (p<0.05; see Table 2.11). Moreover, with this data I failed to find any significant correlation for kMMT accuracy with any continuous variable collected or calculated (see Appendix Table B.2.4).

TABLE 2.11 – Correlations (*r*) among kMMT Accuracy and Practitioner demographics. *p* (2-tailed) <0.05.†

Practitioner Demographic	kMMT Accuracy	Age (years)	Years in Practice	Years Practicing kMMT
Age (years) *p-value*	-0.0175 *0.91*			
Years in Practice *p-values*	-0.0080 *0.96*	0.6030 *<0.01*		
Years Practicing kMMT *p-values*	-0.0175 *0.91*	0.5157 *<0.01*	0.6908 *<0.01*	
Hours/day use kMMT *p-values*	-0.0133 *0.93*	0.1420 *0.37*	0.4680 *<0.01*	0.2748 *0.08*

kMMT, kinesiology-style Manual Muscle Testing; † n=48 - 2 non-responders = 46 in the sample.

= kMMT Accuracy correlations; = Correlation (r) which reached significance (p<0.05).

2.4.3 Post Hoc Analyses

Many practitioners that I met during data collection asked me if practitioners from one technique system were more accurate than from any other system. Curious myself, I considered doing this analysis. However, due to the fact that this study was powered for a sample size of n=48 Pairs, the smaller sizes of the sub-samples (n=2 to 22 Pairs; see Table 2.12 for the breakdown), comparing individual technique systems to each other using statistical methods may have lacked sufficient power to be meaningful. Its limited relevance becomes even more questionable when one considers that many Practitioners (n=17) reported using multiple kMMT technique systems (whereas 29 reported using only 1, and 2 did not respond). However, appeasing my curiosity, I did conduct an analysis comparing the kMMT accuracies of the two most frequently reported systems,

Neuro Emotional Technique (NET) and AK, and all the others combined. The mean accuracy (95% CI) of the NET practitioners (n=22) was 0.676 (0.622 - 0.731), for AK practitioners (n=17), 0.658 (0.602 - 0.714), and for all others combined (n=40), 0.652 (0.610 - 0.695). I found no significant difference between these three groups, yet they were all significantly different from Chance[xii] (see Table 2.12). For a more detailed summary of the scores by technique system, see Appendix Table B.2.5.

During data collection, a considerable difference in testing environments was noted, most remarkably about noise and nearby activity levels. Therefore, a post hoc analysis was performed to determine if the results from one testing site ("Location X"), which was particularly loud, differed from the other testing sites. The mean kMMT accuracy (95% CI) at Location X was 0.627 (0.513 - 0.741), whereas for those Pairs not tested at this site, the mean accuracy was 0.668 (0.631 - 0.705). Although the mean kMMT accuracy was less for Location X, the difference between these two groups did not reach significance (p=0.46). See Table 2.13.

TABLE 2.11 - kMMT Accuracy by kMMT Technique System. Neuro Emotional Technique vs. Applied Kinesiology vs. All Others Combined.

kMMT Technique System	#	kMMT Accuracy	95% CI	kMMT Accuracy Range	*p*-value Compared to Chance**	*p*-values NET vs.	*p*-values AK vs.
Neuro Emotional Technique (NET)	22	0.676	0.622 - 0.731	0.421 - 0.875	**<0.01***	—	—
Applied Kinesiology (AK)	17	0.658	0.602 - 0.714	0.500 - 0.917	**<0.01***	0.620	—
All Others Combined†	40	0.652	0.610 - 0.695	0.400 - 0.875	**<0.01***	0.478	0.876

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; * significance reached; ** Chance here refers to the hypothetical situation where either outcome (strong or weak) was equally likely: 50-50. † Other kMMT Technique Systems (# Practitioners) included: Total Body Modification (6), BodyTalk (4), Health Kinesiology (4), Touch for Health (4), Contact Reflex Analysis (3), Psych-K (3), Clinical Kinesiology (2), Kinesionics (2), Nutritional Response Testing (2), and 1 Practitioner each of: Be Set Free Fast (BSFF), Belief System Technique, BioKinesiology, Energy Kinesiology, GeoTran Integrations, Lifeworks, Nambudripad's Allergy Elimination Techniques (NAET), Neural Organization Technique (NOT), Sacro Occiptial Technique (SOT), Soft Tissue Orthopedics (STO), Thought Field Therapy (TFT), Wellness Kinesiology, Wholistic Kinesiology.

TABLE 2.13 – Post Hoc Analysis of Testing Locations. kMMT Accuracy Location X compared to all other locations combined.

		kMMT Accuracy		
	n	**Mean**	**95% CI**	***p*-value**
Location X	10	0.627	0.513 – 0.741	0.4639
NOT Location X	38	0.668	0.631 – 0.705	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval

2.4.4 Adverse Events

In all testing locations, aside from TP arm fatigue, there were no adverse events reported from any testing.

2.5 Discussion

It is essential to know the accuracy of any diagnostic test in order for its clinical usefulness to be established. With the widespread use of kMMT and with its clinical validity often questioned, estimating its accuracy is the important first step in determining its usefulness.

2.5.1 Statement of Principal Findings

kMMT used for distinguishing false from true spoken statements was found to be significantly more accurate than either Chance or Intuition. Furthermore, there seems to be no correlation between kMMT accuracy and Intuition accuracy: if a Practitioner was accurate at kMMT it did not mean he would also be accurate at Intuition, or not accurate at Intuition, or either vice versa. Likewise, no correlation was found between kMMT accuracy for True vs. False Statements: if a Practitioner scored highly accurate for False Statements, it did not imply he would score accurately for True Statements, or vice versa.

In addition, since no significant difference was found between kMMT accuracy while the Practitioner was Blind (Blocks 1-4) and when the Practitioner was Not Blind (Blocks 1-4), this seems to indicate that Practitioners honestly reported their results and/or they could not be persuaded to bias the kMMT – whether Blind or not. Since the kMMT accuracy for the Misled condition was not 0.000 as theoretically it could have been, this suggests that Practitioners could not be persuaded to bias the kMMT – even when being misled. Since the kMMT accuracy for the Misled condition was less than for the Blind condition ($p<0.01$), it could have been that the Pairs were simply fatiguing, since the Misled condition took place last (Blocks 5 & 6). However, since there was no significant difference between the kMMT accuracy in the Blind condition of Blocks 5 & 6 and the kMMT accuracy in the Blind condition of Blocks 1-4, fatigue is an unlikely explanation. Finally, since the drop in kMMT accuracy in the Misled condition reached significance ($p< 0.01$) and since Intuition accuracy also dropped (but not significantly; p= 0.11), this could mean that Practitioners started to doubt themselves while being misled. Regardless of the reason, it appears from these results that Practitioners honestly reported their results and/or they could not be persuaded to bias the kMMT.

Diagnostic accuracy can also be expressed in terms of sensitivity and specificity, and PPV and NPV. Since kMMT sensitivity was calculated to be 0.568 (95% CI 0.504 - 0.633) and specificity, 0.734 (95% CI 0.687 - 0.782), these findings suggest that about 57% of the time Lies were classified correctly, and about 73% of the time, Truths were classified correctly (which is the identical findings for False and True Statements alone – see Appendix Table B.2.2). Correspondingly, a PPV of 0.663 (95% CI 0.607 - 0.781) implies that, in this testing scenario with a mean prevalence of Lies of 0.47 (95% CI 0.45 – 0.50), if the kMMT went “weak”, there is a 66% chance that the statement was a Lie.

Likewise, a NPV of 0.667 (95% CI 0.625 - 0.708) suggests that if the kMMT stayed "strong", there is a 67% chance that the statement was a Truth. Since both PPV and NPV will vary with prevalence, should the prevalence of Lies change, the PPV and NPV may change as well. For example, if the prevalence of Lies should increase, it is likely that the PPV would decrease and the NPV would increase, correspondingly. Translating this specifically into the context of this study, if the greater the prevalence of Lies, the more surety one can have that a statement giving a weak kMMT result was is Lie (PPV); and analogously, the lower the prevalence of Lies, the more certain that a statement following a strong kMMT result was actually a Truth (NPV).[106] Since the actual prevalence of Lies is not usually known, the predictive values reported here should not be applied universally.

Also interesting were the differences in the Confidence ratings for both the TP and the Practitioner. It seems that for kMMT-naïve TPs, merely participating in this study served to elevate their confidences significantly. Some cynics have noted a similarly heightened belief in processes they call "ideomotor actions" following a positive personal experience.[115, 116] However, since there was no correlation between kMMT accuracy and increase in any TP Confidence rating (see Appendix Table B.2.6), I am disinclined to attribute this to an ideomotor-like experience. (See below for a further discussion of the Ideomotor Effect.) On the other hand, for Practitioners, participation made no difference in their Confidence ratings. Plus, their kMMT accuracy scores were not correlated with their change in Confidence ratings (see Appendix Table B.2.7).

Another notable finding is the ***lack*** of detection of factors that influence kMMT accuracy. Another study on MMT reported finding that those practitioners with at least 5 years' experience achieved a 98% accuracy compared to those practitioners with less than 5

years' experience who achieved a 64% accuracy.[27] Conversely, my results failed to find a correlation between practice experience and kMMT accuracy.

Despite testing for a range of participant characteristics, no significant correlation was found between kMMT accuracy and any of the following:

- Practitioner's profession
- Practitioner's years of practice
- Practitioner's years practicing kMMT
- Practitioner's practice status
- Usual hours per day using kMMT
- The kMMT technique system(s) in which the Practitioner was trained
- Practitioner's self-ranked kMMT expertise
- Practitioner's or TP's age
- Practitioner's gender
- Pair's sameness of gender
- TP reported guessing the paradigm
- TP wearing glasses
- Choice of Practitioner's or TP's arm
- Testing location
- Practitioner's confidence in his own kMMT ability (before or after testing)
- Practitioner's confidence in kMMT in general (before or after testing)
- TP's confidence in kMMT in general (before or after testing)
- TP confidence in paired Practitioner (before or after testing)

- TP's confidence in paired Practitioner's kMMT ability (before or after testing)
- Practitioner's confidence in using kMMT on his paired TP (after testing)

While finding no relationships is interesting, and somewhat puzzling, it may simply mean that the measures or methods employed or my sample size was inadequate to educe the connection.

Finally, the only significant relationship detected seemed to be that with male TPs, a higher kMMT accuracy score was achieved compared to female TPs. This seems to suggest that males may be "easier" to muscle test accurately than females. This in itself is interesting when considering a number of points. Firstly, females seem to be more proficient than males at nonverbal sensitivity and social functioning.[113, 114] Secondly, these results that males are easier to test accurately than females is perplexing since it is the opposite of what I find is widely believed among kMMT practitioners: I have often heard it said that men are more difficult to test because of their greater arm "strength" or their unwillingness to allow their arms to go weak or relinquish "control" of their arm. Thirdly, this is especially interesting because of the finding that kMMT was equally accurate whether a TP's dominant arm or non-dominant was used. All told, this leads me to speculate that arm "strength" has little to do with kMMT and how accurate it can be.

In summary, while many intriguing results emerged from the data collected, the most noteworthy finding of this study was that kMMT was used to accurately distinguish lies from truth. The second most intriguing result was the failure to detect any correlation with any of the potential influencing factors listed above.

2.5.2 Strengths and Limitations

Noting the compelling nature of this new evidence, one must keep in mind the limitations of this study. However, many of its features can be viewed as both a limitation and a strength. For example, while every effort was made to simulate real clinical settings, there were occasions when this was impossible: Certain testing locations were loud and disruptive – and therefore, offered less than ideal testing conditions. However, since the scores did not differ significantly, either a distracting environment does not make a difference to kMMT accuracy, or other testing sites were equally distracting.

In addition, the heterogeneity of the samples can be considered a limitation and a strength. Heterogeneity of Practitioners is a strength in that any type of kMMT practitioner was recruited, regardless of practitioner-type, professional standing, kMMT-style, kMMT technique practiced, or length or extent of practice experience. In addition, in order to be as clinically authentic as possible, Practitioners were allowed to test the way they usually test, within the few confines of this research scenario. While this is a strength, this methodology may be criticised for not being a realistic clinical setting. It may be further criticised for not strictly controlling kMMT methods, for instance, by not utilising force plates to monitor the amount of force Practitioners apply during the kMMT, or by not using strictly standardised muscle testing procedures. These concepts were considered and rejected for the following reasons. Firstly, this study attempted to reproduce a real clinical setting, and force plates are not routinely used in clinical practice. Supporting this decision, previous studies using force plates showed a distinct difference between muscles labelled "strong" and "weak",[3, 25, 26] making their use in this study redundant. Secondly, in clinical practice, kMMT styles vary widely from practitioner to practitioner, so again to simulate a real clinical setting, Practitioners were

allowed to choose their own kMMT style. Prior research has shown that the shape of force curves did not differ between *styles* of muscle testing, only between "strong" and "weak" muscles.[11] Therefore, for these reasons force plates and strict testing protocols were purposely omitted.

Also, while a heterogeneous sample of TPs was sought (i.e. people from a variety of educational, socioeconomic and age range groups), the use of *only* kMMT-naïve TPs introduced a degree of homogeneity into this sample, and as a result, nothing is known about kMMT accuracy using patients already familiar with its methods, which naturally would account for a large percentage of a kMMT practitioner's clientele.

Further to this, in actual clinical settings, patients normally seek out muscle testing practitioners for specific real concerns, perhaps even having been referred to a specific practitioner explicitly for kinesiology. In this study, TPs (1) were healthy (i.e. were not actively seeking treatment); (2) did not have a choice of practitioner – pairs were assembled at random and by convenience; (3) were naïve to kMMT whereas patients typically present to kMMT-practitioners of their own volition, and are usually somewhat aware of what will occur during a session; and (4) again, were kMMT-naïve, whereas real patients are only kMMT-naïve on one occasion, and then on subsequent visits, they would not be naïve. By far the majority of patients of kMMT practitioners would fall into the category of non-naïve, which was not the case in this study. Therefore, for these reasons, replication of an ideal clinical setting was not achieved.

Clear strengths of this study include a high degree of blinding and the choices of reference standard and target condition. It is commonly thought that practitioners can introduce a great deal of bias during kMMT, and therefore, care was taken to control this

bias. One way to limit practitioner bias was accomplished through random blinding of Practitioners. Similarly, it is thought that patients can introduce bias in kMMT by letting their arms go weak at will, an example of response bias[39, 109] or social desirability bias;[110] however, much effort was made to keep TPs blind as well. Furthermore, the choices of reference standard and target condition were clear and well-defined. In studies of diagnostic test accuracy, it is presumed that the target condition is either present or absent,[7] and ideally, the best available method for detecting the presence or absence of the target condition is used as the reference standard.[47] Ideally, studies of diagnostic test accuracy employ a true "gold" standard, which demonstrates perfect accuracy in distinguishing the presence or absence of the target condition. However, perfect gold standards are rare in medical testing, so an imperfect reference standard is normally used.[117] In this study, the reference standard was the actual verity of the spoken statements, which was definitively known to be either true or false – a perfect reference standard – and therefore, it may be considered a true "gold" standard.

A weakness of this study is that kMMT was only compared to one other index test (i.e. Intuition), rather than to other widely-used methods of lie detection, such as polygraph[118] and other methods used in forensic science[119] and detecting "tells" in poker.[120] Another limitation of this study is its lack of generalisability to other applications of kMMT. While kMMT may be useful in distinguishing false statements from true statements, kMMT may not be useful for any other application, such as detecting a food allergy[90, 94] or the need for foot orthotics,[121] a specific mattress,[122] homeopathy[123] or a nutritional supplement.[34] This point is important to emphasise due to the widespread and varied use of kMMT.

2.5.3 Comparisons to Other Studies

There has only been one other study published that attempted to estimate the accuracy of kMMT to distinguish truth from lies. The study done by Monti et al.[25] was similar to this study in that kMMT is used to detect true statements; however, there are dissimilarities as well. TPs (n=89) only spoke 4 statements, 2 true and 2 false, and it appears that only one practitioner performed all the muscle testing, however this was not stated explicitly. This latter point is not apparent because the authors make reference to other individuals involved in this study as "examiners" and "testers" (plural intended). This ambiguity lends itself to confusion. Another limitation of this study is that the degree of practitioner blinding is not clear.[25] For instance, one statement used in this study was: "*My name is* _____." Each TP spoke two "*My name is* _____" statements, one true and one false. For the false statements, males inserted "Alice" and females, "Ralph." While it is not reported if the practitioner in this study was blind to the verity of these statements, it is suspected that blinding is unlikely. The two other statements spoken by the TP were "*I am an American*," and "*I am a Russian*." Since being an American citizen was one inclusion criterion for participants, it is also likely that the practitioner also knew the verity of these statements as well; however this also was not stated explicitly. Finally, the degree of TP blinding was not apparent either. While it was clearly stated that TPs were all kMMT-naïve, it was not specified if the TPs knew the paradigm being used (i.e. True → Strong, False → Weak). These are important considerations which may have significantly limited this study's usefulness.

2.5.4 Possible Explanations of Results

The results indicate that there is a statistically significant difference between kMMT and Chance and between kMMT and Intuition, for detecting lies; however, showing there is a difference, does not explain why there is a difference. I will now explore possible explanations as to first why there might be such a difference, and then, other factors that may have led to this difference.

Firstly, since my findings show a significant difference between kMMT and Chance, this rules out the possibility of Chance or "luck" causing the difference. This may be an obvious argument, but one that I felt is important to highlight. During the data collection phase of this research, it was my experience that there are staunch critics of kMMT who vehemently make this assertion. Yet, this blind conviction in many ways resembles that of those kMMT practitioners on the other side of the fence, who "believe" in the process without scientific proof, and during data collection, I have met a good deal of such practitioners. In fact, it is the opposite side of the same coin. Perhaps one day it would be interesting to revisit the argument that *belief* or *faith* are contributing factors, given that a valid measure of these items can be applied.

Second, it has been asserted that it is not kMMT that is used to detect lies, and it is simply that muscle-testing practitioners are skilled at "reading" people. Alternatively, practitioners may be picking up "something else" from patients, like intuition or a gut feeling – or something equally ethereal or indescribable. However, since a significant difference was found between kMMT accuracy and Intuition accuracy, it seems improbable that kMMT practitioners are drawing on other such signs of deceit. On the other hand, using this line of reasoning, it would make sense that kMMT may be just

another somatic reaction to lying. While it is known that specific physiological changes occur when lying,[86, 124-129] it is possible that a muscle weakening after speaking a false statement could be one such change. This remains a question for future research.

Another possible explanation of these results is that the Practitioner and /or the TP may be acting nonconsciously to bias the muscle test. This nonconscious modulation of muscular movement was labelled the Ideomotor Effect by psychologist/physiologist William B. Carpenter in 1852.[130] It is common to attribute the Ideomotor Effect to any unproven, puzzling phenomena, such as dowsing, Ouija boards, automatic writing, the movement of the table and other objects in séances, the motion of a pendulum, Facilitated Communication and muscle testing.[116, 131] However, since the Practitioners were blind to the verity of the spoken statement, it is unlikely that Practitioners could be unwittingly responsible for an ideomotor action. Also, since there was no significant difference between the pairs whose TPs reported guessing the paradigm, and those who did not, it is unlikely that TPs caused an ideomotor response either.

It may be argued that other factors, such as fatigue and learning, may also play roles in the accuracy of kMMT. However, since the accuracy of kMMT in the first block was no different from the last block of regular testing ($p=0.35$), it is unlikely that either had much of an influence. In addition, it was suggested that Practitioners may have "cheated" by seeing a reflection of the TP's screen in his glasses; however, since there was no significant difference in kMMT between pairs whose TPs wore glasses from those that did not, this claim is also unlikely.

Finally, it is also possible that kMMT accuracy in actual clinical settings may differ from the results obtained in this study, as a result of a Hawthorne Effect.[132] Factors such as test

anxiety or the intensity or duration of assessment may have caused Practitioners to miss subtle changes in muscular strength.[133] All these factors may have contributed to a reduction in the kMMT accuracy reported. Another example of a possible Hawthorne Effect influence is my own presence in the testing room. There is a chance that my presence may have influenced the results in some way; therefore, future research may isolate the participants and remove any observers to avoid this possibility. Furthermore, while every effort was made to keep testing conditions similar for all pairs, the nature of the recruitment and data collection made this impossible. In fact, one testing location was particularly disruptive; however, while there was a slight decline in the kMMT accuracies of the group, the difference did not reach significance. Future studies may want to control their testing environments more closely, if possible. Further to the matter of the testing environment, a number of Practitioners commented in their Post-Testing Questionnaires that water should have been made available for TPs, as they believed that dehydration may affect kMMT accuracy. While this claim remains unsubstantiated for kMMT, dehydration does seem to inhibit cognition.[134-136] In some data collection venues, water was available, in others, it was not. An avenue of future research might be to investigate how hydration levels may influence kMMT accuracy.

2.5.5 Implications for clinical practice

These results, showing that kMMT may be useful for distinguishing false from true statements by practitioners trained in kMMT, may have direct and indirect implication for clinicians in various facets of healthcare.

Secondly, with the onset of the Evidence-based Practice movement, there has been a strong emphasis placed on establishing the validity of healthcare practices, yes, among

clinicians, but especially by policymakers. Since kMMT has been estimated to be used by over 1 million practitioners worldwide, this may be indication enough to warrant consideration. Now with some compelling evidence that kMMT may be a valid assessment method, this might encourage a closer look. The result could be more practitioners using kMMT to guide treatment, and policymakers making it more widely available within national and private healthcare plans.

2.5.6 Unanswered questions and future research

The completion of this initial study in this series of 5 studies, which generated meaningful and applicable results, indicates, first and foremost, that the usefulness of kMMT as a diagnostic tool may indeed be assessed, similar to other diagnostic tools. Despite scepticism from both camps – from within conventional medicine and also from within alternative medicine – a robust methodology has now been developed that may serve as a benchmark for future research in the kMMT field.

As is the case with any research, this first study has opened a Pandora's Box of additional questions. For instance,

- *What factors influence kMMT accuracy?*
- *Why is there such a range in kMMT accuracies (40-91%)?*
- *What characteristics or conditions are required to achieve a 90% kMMT accuracy – compared to 40% accuracy?*
- *Is it possible to "learn" to perform more accurate kMMT?*
- *How much influence do the Practitioner and TP each have on kMMT accuracy?*
- *Is Practitioner accuracy stable (reproducible / repeatable)?*

Future research may also wish to address any differences in accuracies between two TP cohorts: kMMT-naïve vs. non-kMMT-naïve. Also, since this study investigated only one application of kMMT, future research is needed to rigorously assess other commonly-used applications of the various forms of kMMT, such as to detect the need for nutritional supplementation[11, 34-36, 137] and chiropractic subluxations.[39, 52, 138] It is acknowledged that clinical investigations of complementary and alternative medicine techniques are difficult because of factors such as the use of complex, individualised treatments, lack of standardisations,[91] differing treatment outcome philosophies, lack of appropriate outcome measures, and the importance of the therapeutic relationship.[139] Therefore a consensus on basic diagnostic parameters of such conditions must first be reached before rigorous studies of diagnostic test accuracy can be undertaken. I suggest that future research on analogous conditions should first focus on establishing concrete operational definitions, and then on developing a reference standard measure for meeting diagnostic criteria.

It also could be argued that dissecting the kMMT out of a technique system and examining it separately would render meaningless results. Obviously, this is not the case, as the results of this study can be meaningfully applied to any system that uses kMMT to detect lies (or truths). Furthermore, despite the apparent differences in kMMT technique systems, they use kMMT in fundamentally similar ways. Therefore, I maintain that as long as the Practitioner understands the paradigm being used, and agrees on the interpretation of the dichotomous result (i.e. what a "strong" response means as opposed to a "weak" response for each kMMT posed), that the utility of specific applications of kMMT can be satisfactorily investigated using scientific methods. It could be further

argued that each kMMT technique system should be evaluated for its effectiveness as a whole, using rigorous scientific methods such as randomised controlled trials.

2.6 Summary

In this study kMMT was used with significant accuracy to distinguish lies from truths, compared to both Intuition and Chance. This demonstrates that it is possible to develop a robust methodology for assessing the value of kMMT as a diagnostic tool. Nevertheless, despite tracking on a variety of testing characteristics, no one factor was identified that seemed to influence kMMT accuracy. Strengths of this study include a high degree of blinding, the heterogeneity of the samples, the choice of a clear target condition, and the choice of a "gold standard" as the reference standard. The main limitation of this study is its lack of generalisability to other applications of kMMT.

2.7 Chapter 2 – List of Tables and Figures

2.7.1 Tables

TABLE 2.11 - Correlations (r) among kMMT Accuracy and Practitioner demographics. p(2-tailed)<0.05.

TABLE 2.12 - kMMT Accuracy by kMMT Technique System. Neuro Emotional Technique vs. Applied Kinesiology vs. All Others Combined.

TABLE 2.13 - Post Hoc Analysis of Testing Locations. kMMT Accuracy Location X compared to all other locations combined.

2.7.2 Figures

FIGURE 2.1 – Examples of kMMT testing positions. (A) Both Practitioner and Test Patient seated, facing each other; (B) The Test Patient seated and the Practitioner standing to one side; (C) The Test Patient seated and Practitioner standing in front; (D) Both Test Patient and Practitioner standing, with the Practitioner behind; and (E) & (F) Both the Test Patient and the Practitioner standing, with the Practitioner in front to one side. Note also the variations of shoulder position, that in (B) the thumb of the Test Patient is down, and that in (C) the elbow of the Test Patient is bent.

FIGURE 2.2 – Testing scenario layout. (A) Blocks 1-4; (B) Blocks 5-6. The Practitioner (blue) viewed a monitor (also blue) which the Test Patient could not see and entered his results on a keyboard. The Test Patient (red) viewed a monitor (also red) which the Practitioner could see, has an ear piece in his ear through which he receives instructions, and used a mouse to advance his computer to the next picture/statement. Note that while in Blocks 1-4, the Practitioner was presented with either the *same* picture as the Test Patient or a blank, black screen, while in Blocks 5-6, a third possibility is introduced: a picture which was *different* from the Test Patient's picture.

FIGURE 2.3 – Participant Flow Diagram : Study 1.

FIGURE 2.4 - Flowchart for one kMMT / Intuition. Participant pairs performed 10 repetitions of this series per Block. kMMT Blocks were alternated with Intuition Blocks, and each pair performed 6 Blocks of each (kMMT & Intuition).

FIGURE 2.5 – Examples of visual stimuli. (A), (B) and (C) are examples that could have been presented to either the Test Patient or the Practitioner, while (D) – a blank, black screen – could have been presented only to the Practitioner.

FIGURE 2.6 - Histogram showing normal distributions of accuracies - indicating use of t-test statistic is appropriate (n=48). (A) kMMT (40 tests), while Practitioner was Blind (Blocks 1-4 only), (B) Intuition (40 Intuits), while Practitioner was Blind (Blocks 1-4 only).

FIGURE 2.7 – Scatterplot of kMMT Accuracy vs. Intuition Accuracy – when the Practitioner is Blind (Block 1-4 only).

FIGURE 2.8 – ROC Spaces and ROC Curve for kMMT. (A) Shadow area represents better performances; (B) Those above the red diagonal had a tendency toward finding strong kMMT responses, while those below the red diagonal had a tendency toward weak kMMT responses; (C) ROC Curve. [In Blocks 1-4 only, when the Practitioner was Blind (n=48 pairs)].

FIGURE 2.9 – kMMT Accuracy by Block with 95% confidence intervals.

CHAPTER 3

Study 2 – Replication of Study 1

"No amount of experimentation can ever prove me right;

a single experiment can prove me wrong."

Albert Einstein

CHAPTER 3 : STUDY 2 – REPLICATION OF STUDY 1

3.1 ABSTRACT

Research Objectives: To replicate Study 1 (Chapter 2, page 47) using a simplified methodology, and to estimate the accuracy (overall fraction correct) of kinesiology-style manual muscle testing (kMMT) used to distinguish lies from truth in spoken statements.

Methods: A prospective study of diagnostic test accuracy was carried out. Twenty Practitioners who routinely practised kMMT were paired with Test Patients (TPs) who may or may not have been kMMT-naïve. The Pairs performed 40 kMMTs as TPs spoke True and False statements. Blocks of kMMT alternated with blocks of Intuition. The verity of the spoken statements was randomly assigned, with the prevalence of Lies fixed at 0.50.

Results: kMMT accuracy was found to be 0.594 (95% CI 0.541 - 0.647), which was significantly different from Intuition accuracy (0.514; 95% CI 0.483 - 0.544; p=0.01) and Chance (0.500; p<0.01). These results fell within or close to the 95% Confidence Intervals of Study 1. Also, similar to the previous study (see page 88), testing for various factors that may have consistently influenced kMMT accuracy failed to detect any correlations.

Summary: This study successfully replicated Study 1 by again finding that kMMT can be used with significant accuracy to distinguish lies from truths, compared to both Intuition and Chance. Moreover, this study further supports the concept that a simple yet robust methodology for assessing the value of kMMT as a diagnostic tool can be developed and implemented effectively. Comparable to Study 1, no factors were identified that seemed to

consistently influence kMMT accuracy. Also similar to Study 1, the main limitation of this study is its lack of generalisability to other applications of kMMT.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; lie detection; deception; lying; intuition; arm; upper extremity

3.2 Introduction

When the results of an experiment are other than what was expected, a natural inclination is to want to repeat the study to see if its results could be replicated. This was the main reason for doing Study 2: To repeat Study 1 to see if kMMT could again be used to accurately distinguish lies from truth. So, using the knowledge gained from the first study, a subsequent study was designed which featured the salient points of Study 1, with some modifications aimed at simplifying the methods while improving its robustness.

Through the experiences of Study 1, much was learned about the recruitment of participants and the data collection processes. Firstly, since the primary outcome was measured only when the Practitioner was blind, the use of two computers in Study 1 added awkward logistics and unnecessary complexity. Therefore, in Study 2, the Practitioner's computer was removed, leaving him blind to the verity of the TP's statement for the entire study. Secondly, another problematic part of Study I was removed: Blocks 5 & 6. In these blocks, I attempted to deceive the Practitioner into biasing the muscle test. Since the kMMT accuracy in these blocks was similar to the earlier blocks, it appears that this study design failed to encourage bias. Since the potential for practitioner bias is a recurring criticism of kMMT, this issue is important, but is presently left for future research. Therefore, methodologically, Study 2 is a simplified version of Study 1.

In addition, recruitment of TPs was widened to include those with prior kMMT experience and those who knew their Practitioner. This was modified after having considerable difficulty recruiting TPs who met the strict enrolment criteria of Study 1 (see page 52), in the locality of the already-enrolled Practitioner. So, in Study 2, the TP enrolment criteria were relaxed for convenience, and also I thought it would be interesting to see what results a stratification of TPs would produce.

One other change in the protocol was that whilst in Study 1 I was present, in Study 1 I was not present during the testing (i.e. I left the room). It has been suggested that I, as a clinician who uses kMMT regularly in practice, may possess a certain bias toward the validity of this tool; therefore, it was possible that the results of Study 1 may have been influenced by my presence. For instance, I may have unintentionally displayed subtle signs when the TP was lying which I did not when the TP was telling the truth, or vice versa. Irrespective of the legitimacy or otherwise of these claims, once the pair was ready to begin testing, I left the room until they were finished.

Because in Study1 I observed that Practitioners often seemed anxious prior to testing, I was curious if an anxious state influenced performance.[140] Therefore, a question about anxiety was added to the Practitioner's Pre-testing Questionnaire. In this question, Practitioners were asked to rate their level of subjective state anxiety using a 10cm Visual Analog Scale (VAS). A VAS was chosen over more commonly-used anxiety measures, like the State-Trait Anxiety Inventory (STAI), because of self-report ratings, VASs have been found to have the greatest sensitivity and the least susceptibility to bias,[141] plus they are simple to use.

Finally, the prevalence of Lies in this study was fixed at 0.50. Since the prevalence of the target condition naturally varies with clinical setting and patient-mix, I wished to examine the effect a fixed prevalence had on kMMT accuracy. This is different to Study 1, where the prevalence of Lies varied from Pair to Pair around a mean prevalence of 0.47.

Each of these changes was successfully implemented into the protocol of Study 2. Besides these, all other aspects were identical: the primary and secondary index tests, the reference/gold standard test, the target condition, the testing positions and layout, the stimuli, the remainder of the questionnaires, etc. Finally, the study aim was identical: To estimate the

accuracy of kMMT to distinguish lies from truth when the practitioner was blind. In the next section, I will briefly outline the methods again.

3.3 Methods

This study is a prospective study of diagnostic test accuracy. No participant was assessed prior to enrolment. This protocol received ethics committee approval by the Oxford Tropical Research Ethics Committee (OxTREC; Approval #41-10) and the Parker University Institutional Review Board for Human Subjects (Approval # R15_10). Also, this study protocol was registered with two clinical trials registries: the Australian New Zealand Clinical Trials Registry (ANZCTR; www.anzctr.org.au), and US-based ClinicalTrials.gov. Written informed consent was obtained from all participants, and all other tenets of the Declaration of Helsinki were upheld. This paper was written in accordance with the Standards for the Reporting of Diagnostic Test Accuracy Studies (STARD) guidelines (see Appendix D, page 372, for the STARD Checklist).[47, 66, 99]

Fundamentally, the methodology of this study followed the same basic structure as Study 1 (See page 51), with the following exceptions:

(1) Throughout this study, the Practitioners in this study were not intermittently blind, but completely blind to the verity of the TP's statement;
(2) The sample size was reduced to 20 pairs;
(3) TPs who were *not* kMMT-naïve were included;
(4) Some TPs were acquainted with their Practitioners;
(5) The number of kMMTs & Intuitions were reduced from 60 each to 40 each;
(6) The blocks where the Practitioners were misled were removed;
(7) I, the Principal Investigator, was not present in the room during testing;

(8) Practitioners were asked to rate their subjective state anxiety prior to testing; and

(9) The prevalence of Lies was fixed at 0.50.

Other than these features, the methodology of this study remained consistent to Study 1 (see page 51).

3.3.1 Participants and Setting

Two groups of participants were recruited: (A) Healthcare practitioners (n=20) who routinely use kMMT in practice ("Practitioners"), and (B) Test Patients (n=20; "TPs"). Practitioners and TPs were recruited in the same manner as in Study 1 (see page 52), in the American states of Texas, New York, Arizona and California. The enrolment criteria for this study were similar as well, except also included were those volunteers who were *not* naïve to kMMT, and also those that knew the Practitioner. See Table 3.1 for a summary of enrolment criteria. Another difference was that when participants were ready to begin the testing phase of this study, I left the room.

TABLE 3.1 – Participant enrolment criteria – Study 2

Practitioner (n=20)	**Test Patient** (n=20)
• Aged 18-65 years • Fully functioning & painfree arms • Fluent in English • Not visually-impaired, deaf or mute • Any type of healthcare professional • Uses kMMT regularly in practice • Uses any kMMT technique(s) • Any amount of kMMT experience • Any amount of kMMT expertise • Any number of years in practice	• Aged 18-65 years • Fully functioning & painfree arms • Fluent in English • Not visually-impaired, deaf or mute

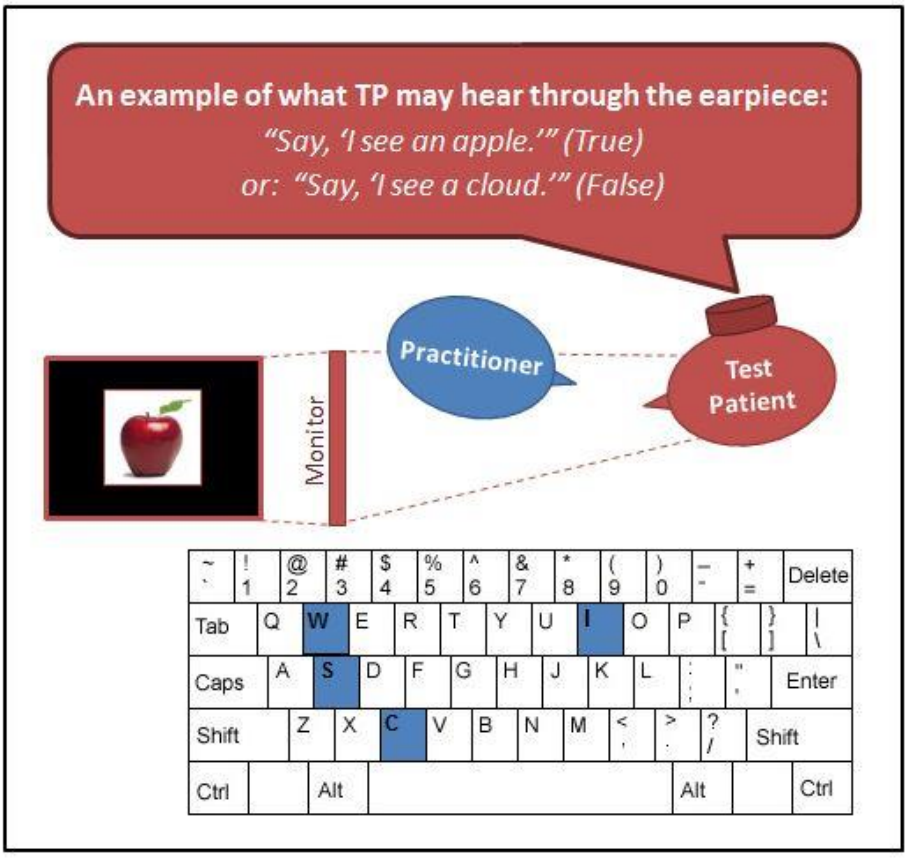
3.3.2 Test Methods

The target condition, index test, reference standard, the secondary index test (i.e. Intuition), study population, and participant recruitment and sampling were identical to Study 1 (see page 51).

3.3.2.1 The Testing Scenario

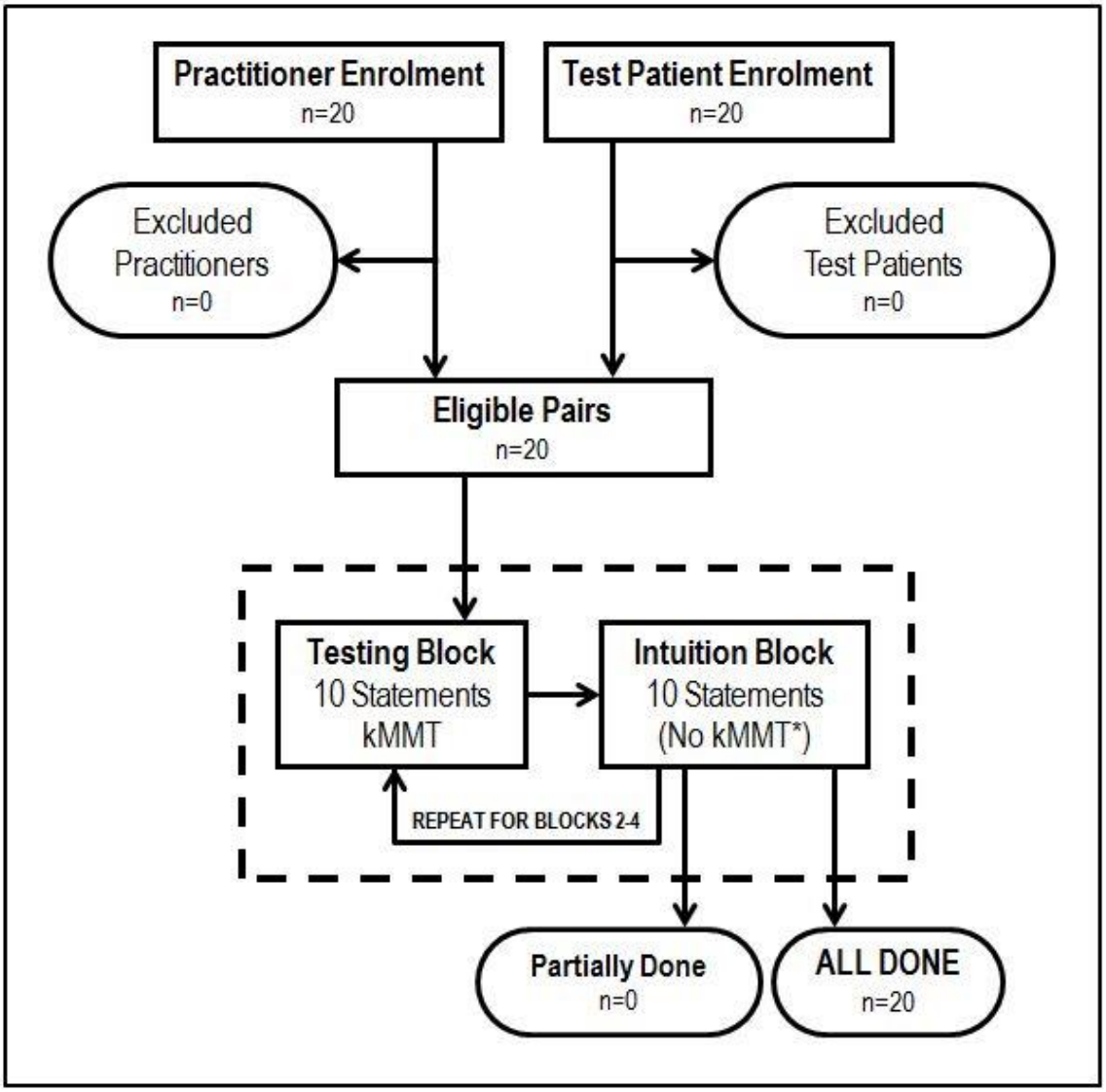
The main difference in the testing scenario of this study compared to Study 1 was that only the TP viewed a computer screen: The Practitioner did not. Still, the Pairs were positioned in such a way so that the Practitioner could not see the TP's screen. One of the reasons I made this change was that during Study 1, I had to repeatedly remind Practitioners to look at their computer screen prior to testing, which many seemed to dislike. See Figure 3.1 for a layout of the testing scenario for this study.

FIGURE 3.1 – Testing scenario layout: The Test Patient (red) viewed a monitor which the Practitioner could see, had an ear piece in his ear through which he received instructions. After the muscle test, the Practitioner (blue) entered his results on a keyboard.



Each Practitioner performed 40 kMMTs on the TP, broken up into 4 blocks of 10 tests each and recorded their results in the same way as in Study 1 (see page 66). Four (4) Intuition Blocks alternated with 4 kMMT Blocks. See Figure 3.2 for the Participant Flow Diagram.

FIGURE 3.2 – Participant Flow Diagram : Study 2



kMMT, kinesiology-style Manual Muscle Testing; *Touching wrist & observing

The stimuli presented were randomly selected from the same database of 100 affect-neutral pictures/statements used in Study I. DirectRT™ Research Software (Empirisoft Corporation, New York, NY) was programmed to present a unique sequence of stimuli for each Pair, while randomizing the verity of the statements (i.e. True or False). Another difference of this study

was that the prevalence of False Statements was set constant at 0.50. Finally, participants completed similar pre- and post-testing questionnaires as in Study 1 (see page 68; and Appendix A, page 244); however, a question about the Practitioner's subjective state anxiety was added to the Pre-Testing Questionnaire. This question used a similar 10cm VAS, comparable the questions about Confidence ratings, with the left end anchored with "None," and the right end, "Worst Ever" (see Appendix A, page 245).

3.3.3 Statistical Methods

Using the results from Study 1 (see page 75), a new sample size calculation was performed. Using a 95% confidence interval, it was determined that a study with 20 Practitioner-TP pairs would have good statistical power to demonstrate the kMMT could be used to distinguish truth from lies. In addition, subgroup analyses will be shown for completeness, although the study was not powered to make these kinds of comparisons.

Again, since I was mainly interested in estimating how well kMMT can be used to detect lies, I report error-based measures of accuracy: overall fraction correct, sensitivity and specificity[73] – and their 95% confidence intervals (95% CI). Error-based measures will also be reported for Intuition.

Statistical advice was sought, during the design phase and for data analysis for this study. All data were analyzed using STATA 17.0, specifically the commands *ttest* and *pwcorr, sig*.

3.4 Results

3.4.1 Participants

Twenty unique Practitioner-TP pairs were enrolled between July and November 2011. There were 13 female and 7 male Practitioners, and 8 female and 12 male TPs. Of the 20 Practitioners enrolled, there were 14 chiropractors, 2 mental health professionals, 1 acupuncturist, and 3 other health professionals. Fourteen Practitioners were in full-time practice, 4 were in part-time practice, and 2 were not currently practising. The Practitioners' mean (SD) number of years in practice was 17.6 (9.3) years. The mean age for Practitioners was 49.3 (12.0) years, and for TPs, 40.8 (12.1) years. For a summary of Practitioner demographics, see Table 3.2.

TABLE 3.2 - Demographics of Practitioners

	Practitioners (n=20)
Gender (M:F)	7:13
Mean age (SD)	49.3 (12.0)
Mean number of years in practice (SD)	17.6 (9.3)
Practitioner-type (*n*)	
Chiropractor	14
Mental Health Professional	2
Acupuncturist	1
Other Health Professional	3
Practitioner Practice Status (*n*)	
Full-time	14
Part-time	4
Not practising	2
Mean years of kMMT experience (SD)	16.4 (9.0)
Mean hours of kMMT/day (SD)	3.9 (2.4)
Mean self-ranked kMMT Expertise* (SD)	3.2 (0.7)
Median degree of test anxiety**†§ (Min, Max)	0.9 (0, 6.5)
Mean degree of confidence in own kMMT ability (pre-testing)† (SD)	8.9 (0.9)
Mean degree of confidence in kMMT in general (pre-testing)†(SD)	8.7 (1.4)
Type(s) of kMMT Technique(s) used (*n*)††	
Neuro Emotional Technique (NET)	14
Applied Kinesiology (AK)	11
Total Body Modification (TBM)	7
Contact Reflex Analysis (CRA)	5
Neural Organization Technique (NOT)	2
PSYCH-K	3
Other‡	7

kMMT, kinesiology-style Manual Muscle Testing; SD, Standard Deviation; Min, Minimum; Max, Maximum; M, Male; F, Female; SD, Standard Deviation; * Self-ranked kMMT Expertise, ranged from 0=None to 4=Expert; ** Test Anxiety refers to the amount of anxiety the Practitioner was expereincing just prior to testing

†Measured using a 10cm Visual Analog Scale, from 0="None" to 10="Most Ever"; § One Practitioner did not respond to this question; ††Practitoners could respond with more than one technique.

‡ Other kMMT techniques included 1 Practitioner each: Clinical Kinesiology (CK), Directional Non-Force Technique (DNFT), O-Ring Testing, Quantum Neurology, Quantum Reflex Analysis (QRA), Thought Field Therapy (TFT), Touch for Health.

3.4.2 Test Results

Pairs took between 10 and 40 minutes to complete their participation. All Pairs completed all testing in full. Aside from TP arm fatigue, there were no adverse events reported from any testing. Also, I noted that the removal of the Practitioner's computer not only simplified the testing methods, it also appeared to be a more natural and authentic clinical scenario compared to Study 1 (see page 51). All accuracies were normally distributed (see Appendix Figure B.3.1), so parametric statistics were used, mainly the Student t-test and ANOVA.

3.4.2.1 kMMT and Intuition Accuracies

The mean (95% CI) accuracy (i.e. overall fraction correct) for kMMT was 0.594 (0.541 – 0.647), which was significantly different from both the mean (95% CI) Intuition accuracy, 0.514 (0.483 – 0.544; p=0.01), and Chance[i] (p<0.01). The 2x2 tables for each Pair can be found in Appendix Table B.3.1. To calculate sensitivity, specificity, PPV and NPV, I calculated these statistics for each pair and report their means (95% CIs): sensitivity, 0.503 (0.421 - 0.584); specificity, 0.685 (0.616 - 0.754); PPV, 0.613 (0.553 - 0.673); and NPV, 0.583 (0.534 - 0.631). The ROC Curve for kMMT accuracy (i.e. [sensitivity] vs. [1-specificity]) can be found in Figure 3.3.

The same mean statistics are reported for the Intuition Condition in Table 3.3. I again ran several checks. I compared the sensitivity and specificity of kMMT with the mean kMMT accuracies for False Statement only and True Statements only, and found them to be identical, as they should be. See Appendix Table B.3.2. In addition, comparing Table 3.3 to Table 2.6 of Study 1 (see page 74), these mean accuracy statistics were close to or within the 95% CIs of Study 1 (see page 78), and vice versa. That is, the mean kMMT accuracy and

[i] Chance here refers to the hypothetical situation where either outcome was equally likely: 50-50.

NPV obtained in Study 1 fell just above the 95% CIs of the mean kMMT accuracy and NPV of this study, and the mean sensitivity, specificity and PPV of Study 1 (see page 78) fell within the respective 95% CIs of this study, while the mean kMMT accuracy of this study fell just below the 95% CI of the mean kMMT accuracy of Study 1.

TABLE 3.3 – Diagnostic accuracy – as sensitivity, specificity, positive predictive value, and negative predictive value (*n*=20 Pairs) (A) For kMMT; (B) For Intuition.

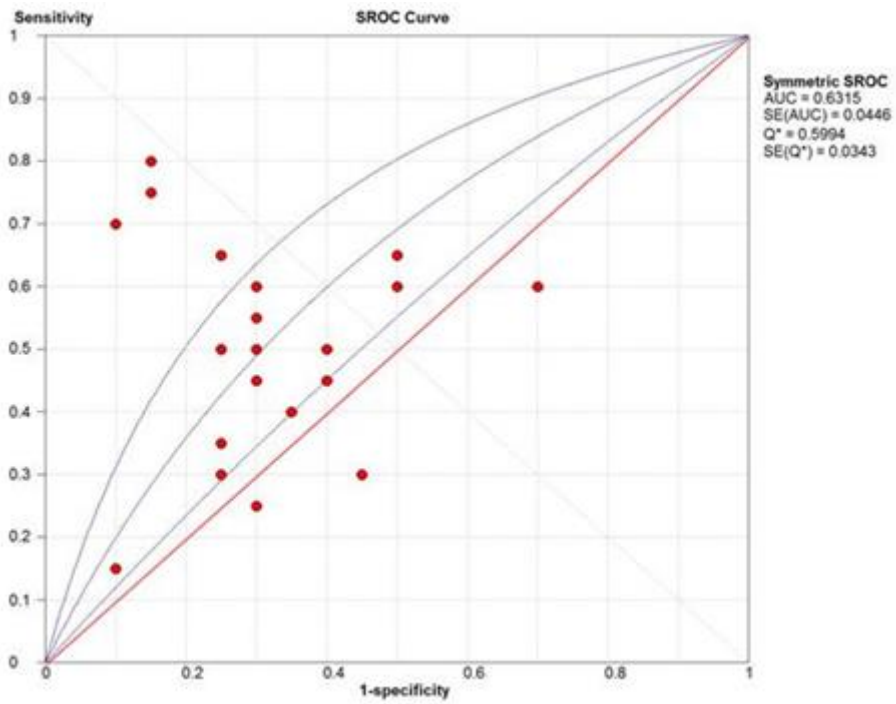
(A) kMMT	n	Mean	95% CI
	20	0.594	0.541 – 0.647
Overall Fraction Correct	20	0.503	0.421 – 0.584
Sensitivity	20	0.685	0.616 – 0.754
Specificity	20	0.613	0.553 – 0.673
Positive Predictive Value	20	0.583	0.534 – 0.631
Negative Predictive Value			

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval

(B) Intuition	n	Mean	95% CI
	20	0.514	0.483 – 0.544
Overall Fraction Correct	20	0.425	0.356 – 0.494
Sensitivity	20	0.603	0.555 – 0.650
Specificity	20	0.494	0.427 – 0.561
Positive Predictive Value	20	0.515	0.490 – 0.540
Negative Predictive Value			

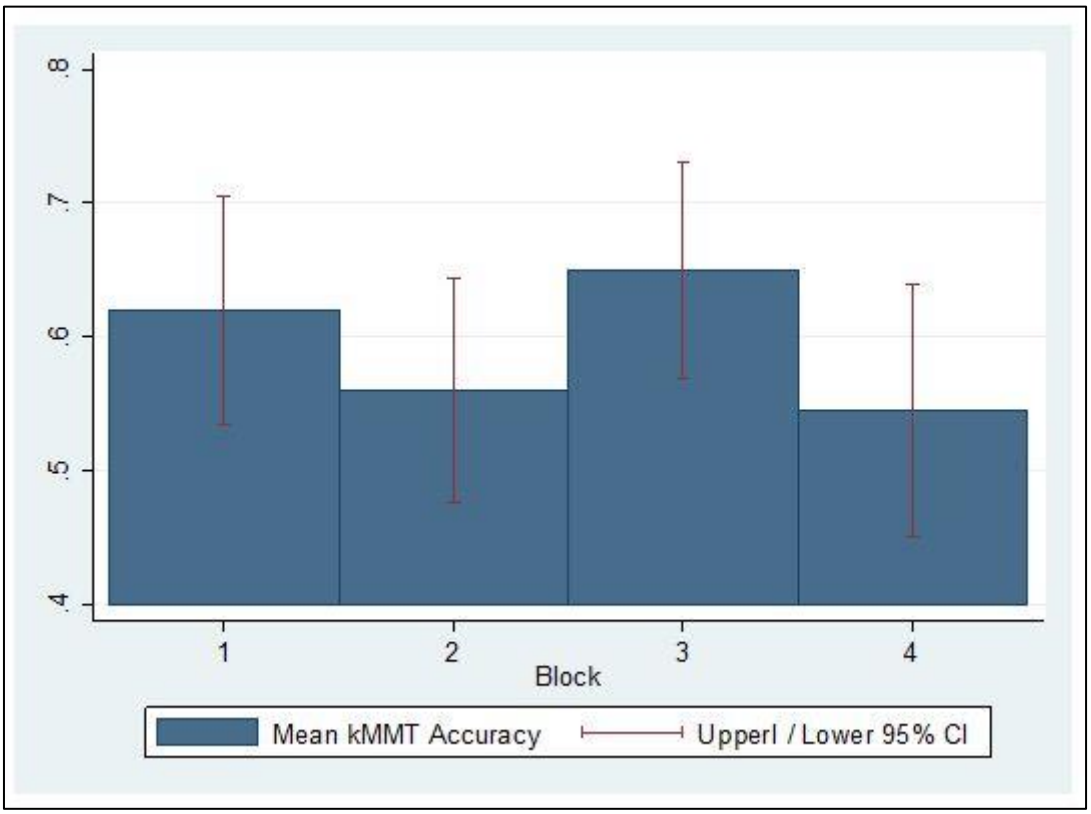
kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval

FIGURE 3.3 – ROC Curve for kMMT. Dots above the red line represent better performances.



Looking at kMMT accuracy by Block, Figure 3.4 shows that there again appears to be no distinct pattern, and in fact, no correlations reached significance (see Table 3.4)

FIGURE 3.4 – Mean kMMT accuracies by Block.



kMMT, kinesiology-style manual muscle testing; CI, Confidence Interval

TABLE 3.4 – Correlations (r) with p-values among kMMT accuracies by Block

	Block 1	Block 2	Block 3
Block 1	1.0000		
Block 2	0.0581	1.0000	
p-value	*0.8078*		
Block 3	0.0000	0.3567	1.0000
p-values	*1.0000*	*0.1226*	
Block 4	0.4331	-0.0936	0.2642
p-values	*0.0565*	*0.6948*	*0.2603*

kMMT, kinesiology-style Manual Muscle Testing.

TABLE 3.5 – The influence on various Practitioner categorical factors on kMMT accuracy. (1) Profession, (2) practising status, and (3) self-ranked kMMT expertise.

(B)	kMMT Accuracy							
	(1) Practitioner Profession		(2) Practitioner Practising Status			(3) Self-ranked kMMT Experise (0-4)*		
	Chiropractors (n=14)	All others (n=6)	Full Time (n=14)	Part Time (n=4)	Not Practising (n=2)	4 (n=7)	3 (n=10)	2 (n=3)
Mean	0.607	0.563	0.561	0.706	0.600	0.611	0.590	0.567
95% CI	0.535 - 0.679	0.478 - 0.647	0.504 - 0.618	0.508 - 0.905	0.000 - 1.000	0.470 - 0.751	0.518 - 0.662	0.387 - 0.746
***p* -value**	0.36		0.07			0.86		

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; * Practitioners were asked to rank their own kMMT ability from 0 ("None") to 4 ("Expert"), No Practitioners responded "0" or "1".

3.4.2.2 Potential Influencing Factors

Again, there may have been participant characteristics that influenced kMMT accuracy; therefore I considered the same specific traits of Practitioners and TPs. First, I looked at Practitioner Profession, Practitioner Practising Status and Practitioner Self-ranked kMMT Expertise. See Table 3.5. Due to the smaller sample size of this study, I broke Practitioner Profession down into only 2 categories: (2) Chiropractors (n=14) and (2) All Others (n=6). Chiropractors had a mean (95% CI) kMMT accuracy of 0.607 (0.535 - 0.679), while All Others achieved 0.563 (0.478 - 0.647), which were not statistically different (p= 0.36). The breakdown of Practitioners' Practising Status was: 14 Full Time, 4 Part Time, and 2 Not Practising. Full Time Practitioners scored a mean (95% CI) kMMT accuracy of 0.561 (0.504 - 0.618), Part Time, 0.706 (0.508 - 0.905), and Not Practising, 0.600 (0.000 – 1.000), and the difference between these groups did not reach significance (p=0.07). For Self-Ranked kMMT Expertise, 7 Practitioners rated themselves as a "4" (i.e. "Expert"), 10 as a "3" and 3 as a "2," while none rated themselves as a "1" or "0." The mean (95% CI) kMMT accuracy for "4"-ranked Practitioners was 0.611 (0.470 – 0.751), for "3"-ranked Practitioners, 0.590 (0.518 - 0.662), and for "2"-ranked, 0.567 (0.387 - 0.746), and their differences by ANOVA did not reach significance (p=0.86).

Stratifying by technique system practiced, I again grouped the Practitioners into 3 groups: (1) NET Practitioners (n=14), (2) AK Practitioners (n=11), and (3) All Others (n=3). See Table 3.6. However, since it is common that kMMT practitioners have been trained in more than one kMMT technique system, it was possible for Practitioners to be included in more than one group. For instance, if Practitioner A practiced NET and TBM, he was put into class (1) and (3), and if Practitioner B practiced NET, AK and CK, he was put into all 3 classes. The NET Practitioners scored a mean (95% CI) kMMT accuracy of 0.579 (0.509 - 0.649), the AK

Practitioners, 0.580 (0.510 - 0.650), and All Others, 0.605 (0.535 - 0.675), and their differences were not significant (p=0.80). Once again, I have included this comparison for completeness; however, due to this cross-pollination and the small sample sizes, this comparison may not be meaningful.

TABLE 3.6 – The influence on kMMT technique system on kMMT accuracy.

kMMT Accuracy	Practitioner's kMMT Technique System(s)†		
	NET (n=14)	AK (n=11)	All Others‡ (n=3)
Mean	0.579	0.580	0.605
95% CI	0.509 - 0.649	0.510 - 0.650	0.535 - 0.675
***p* -value (ANOVA)**		0.80	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval;
† Practitioners may be included in more than one group;
‡ Other kMMT techniques included: Total Body Modification (TBM), Contact Reflex Analysis (CRA), Clinical Kinesiology (CK), Neural Organization Technique (NOT), Directional Non-Force Technique (DNFT), O-Ring Testing, Quantum Neurology, Quantum Reflex Analysis (QRA), Thought Field Therapy (TFT), Touch for Health.

Also, I once again compared Genders: (1) Practitioner Gender, (2) TP Gender, and (3) Sameness of Gender (see Table 3.7). There were 7 male Practitioners who achieved a mean (95% CI) accuracy of 0.593 (0.498 - 0.688), and 13 female Practitioners who achieved a mean (95% CI) accuracy of 0.594 (0.520 - 0.668), and the difference between Practitioners did not reach significance (p=0.98). Likewise, there were 12 male TPs and 8 female TPs, and when their mean (95% CI) accuracies [0.575 (0.507 - 0.643) and 0.622 (0.519 - 0.725) respectively], were compared, unlike these results of Study 1 (see page 87), no significant difference was found (p=0.40). Finally, the sameness of genders of the Pairs was compared. Those Pairs of the same gender (i.e. Male-Male or Female-Female; n=5) achieved a mean (95% CI) kMMT accuracy of 0.625 (0.490 - 0.760), and those Pairs of different genders (i.e.

Male-Female or Female-Male; n=15) achieved a mean (95% CI) kMMT accuracy of 0.583 (0.519 - 0.648), the difference of which was found to be not significant (p=0.49).

Again for completeness, I report the influence of arm choice on kMMT accuracy: (1) Practitioners reported choice of preferred arm (of their own) for performing kMMT, and (2) The use of TP's dominant vs. non-dominant arm during testing. Sixteen Practitioners reported preferring to use their own right arm for kMMT, and this group scored a mean (95% CI) accuracy of 0.598 (0.543 - 0.654), while 4 Practitioners reported preferring to use their own left arm for kMMT, scoring a mean (95% CI) accuracy of 0.575 (0.321 - 0.829), and there was no significant difference in their accuracies (p=0.80). Similarly, during testing, 5 Pairs used the TP's dominant arm and 15 used the non-dominant arm, and achieved kMMT (95% CI) means of 0.620 (0.408 - 0.832) and 0.585 (0.533 - 0.637), respectively, the difference of which was insignificant (p=0.68). See Table 3.8.

TABLE 3.7 – The influence on fixed properties of Participants on kMMT accuracy. (1) Practitioner's gender; (2) Test Patient's gender, and (3) sameness of gender.

	kMMT Accuracy					
	(1) Practitioner's Gender		(2) Test Patient's Gender		(3) Practitioner & TP Gender	
	Males (n=7)	Females (n=13)	Males (n=12)	Females (n=8)	Same (n=5)	Different (n=15)
Mean	0.593	0.594	0.575	0.622	0.625	0.583
95% CI	0.498 - 0.688	0.520 - 0.668	0.507 - 0.643	0.519 - 0.725	0.490 - 0.760	0.519 - 0.648
Minimum	0.475	0.425	0.425	0.475	0.525	0.425
Maximum	0.800	0.825	0.825	0.800	0.800	0.825
***p* -value**	0.98		0.40		0.49	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval;TP, Test Patient.

TABLE 3.8 – The influence on various Pair categorical variables on kMMT accuracy. Choice of Practitioner's and Test Patient's arms.

	kMMT Accuracy			
	Practitioner's Preferred Choice of Own Arm for kMMT		Test Patient's Arm Used	
	Right (n=16)	Left (n=4)	Dominant (n=5)	Non-Dominant (n=15)
Mean	0.598	0.575	0.620	0.585
95% CI	0.543 - 0.654	0.321 - 0.829	0.408 - 0.832	0.533 - 0.637
***p*-value**	0.80		0.68	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval.

Like Study 1, I compared those TPs who reported guessing the paradigm to those who did not, and those TPs who wore glasses to those who did not. Those TPs who reported guessing the paradigm (n=6), scored a mean (95% CI) kMMT accuracy of 0.621 (0.507 - 0.735), and those who did not (n=14), 0.582 (0.515 - 0.650), and while they were both statistically different from Chance[xii] (former, p=0.04, latter, p=0.02), there was no significant difference between them (p=0.49). Likewise, those Pairs whose TPs wore glasses during testing (n=5) achieved a mean (95% CI) kMMT of 0.560 (0.386 - 0.734), which was indistinguishable from Chance (p=0.39), yet likely underpowered. Also, those Pairs whose TPs did *not* wear glasses during testing (n=15) achieved a mean (95% CI) kMMT of 0.605 (0.546 - 0.664), which was statistically different from Chance ($p<0.01$). Also, the difference between these 2 groups not reach significance (p=0.54). See Table 3.9.

Unlike Study 1, Study 2 also included some TPs who: (1) were non-kMMT-naïve, and (2) knew their paired Practitioner (see Table 3.9). Comparing the kMMT accuracy of those Pairs whose TP was *not* naïve to kMMT (n=9) to those Pairs whose TPs *were* kMMT-naïve (n=11), while their difference approached significance, none was found (p=0.07). The mean (95% CI) kMMT accuracy for those Pairs whose TPs were kMMT- naïve was 0.634 (0.555 -

TABLE 3.9 – The influence of various categorical TP characteristics on kMMT accuracy. (1) The Test Patient guessing the paradigm, (2) The Test Patient wearing glasses during testing, (3) TP experience with kMMT, and (4) TP knew practitioner.

	Mean kMMT Accuracies							
	(1) TP Reported Guessing the Paradigm?		(2) TP wore Glasses?†		(3) TP kMMT Naïve?		(4) TP knew Practitioner?	
	Yes (n=6)	No (n=14)	Yes (n=5)	No (n=15)	Yes (n=11)	No (n=9)	Yes (n=3)	No (n=17)
Mean	0.621	0.582	0.560	0.605	0.634	0.544	0.658	0.582
95% CI	0.507 - 0.735	0.515 - 0.650	0.386 - 0.734	0.546 - 0.664	0.555 - 0.713	0.475 - 0.614	0.340 - 0.977	0.525 - 0.639
***p*-value**	0.49		0.54		0.07		0.42	
***p*-value compared to Chance†**	**0.04***	**0.02***	0.39	**<0.01***	**<0.01***	0.18	0.17	**0.01***

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; TP, Test Patient; * Reached significance;

0.713), which was significantly different from Chance (p<0.01), and for those Pairs whose TP was *not* naïve to kMMT, 0.544 (0.475 - 0.614), which was no different than Chance (p=0.018). Correspondingly, those Pairs who knew each other (n=3) achieved a mean (95% CI) kMMT accuracy of 0.658 (0.340 - 0.977), which was possibly underpowered, was found to be no different from Chance (p=0.17). On the other hand, those Pairs who did not know each other (n=17) achieved a mean (95% CI) kMMT accuracy of 0.582 (0.525 – 0.639), which was statistically different from Chance (p<0.01). Also there was no significant difference in the mean kMMT accuracies of these 2 groups (p=0.42).

3.4.2.3 Correlation Testing

Correlations were run among kMMT accuracy and various independent variables. Firstly, I compared kMMT accuracy to the Practitioner demographics of age, number of years in practice, number of years practising kMMT, and usual number of hours per day using kMMT. No significant correlations were detected between kMMT accuracy and any of these variables (see Table 3.10).

TABLE 3.10 – Correlations (*r*) among kMMT accuracy and Practitioner demographics.
p(2-tailed)<0.05

Practitioner Demographic	kMMT Accuracy	Age (years)	Years in Practice	Years Practicing kMMT
Age (years)	0.0394			
p-value	*0.8691*			
Years in Practice	-0.0240	0.7266		
p-values	*0.9222*	*0.0004*		
Years Practicing kMMT	-0.1979	0.6430	0.9018	
p-values	*0.4168*	*0.0030*	*0.0000*	
Hours/day use kMMT	-0.3062	0.0294	0.1662	0.2986
p-values	*0.2023*	*0.9048*	*0.5099*	*0.2287*

kMMT, kinesiology-style Manual Muscle Testing

= kMMT Accuracy; = Correlation (r) which reached significance (p<0.05).

Then, I compared kMMT accuracy to Confidence ratings. Participants were asked to rate their levels of confidence in a number of items. Practitioners rated:

(1) their Confidence in their own kMMT ability, and

(2) their Confidence in kMMT in general;

while TPs rated:

(1) their Confidence in kMMT in general,

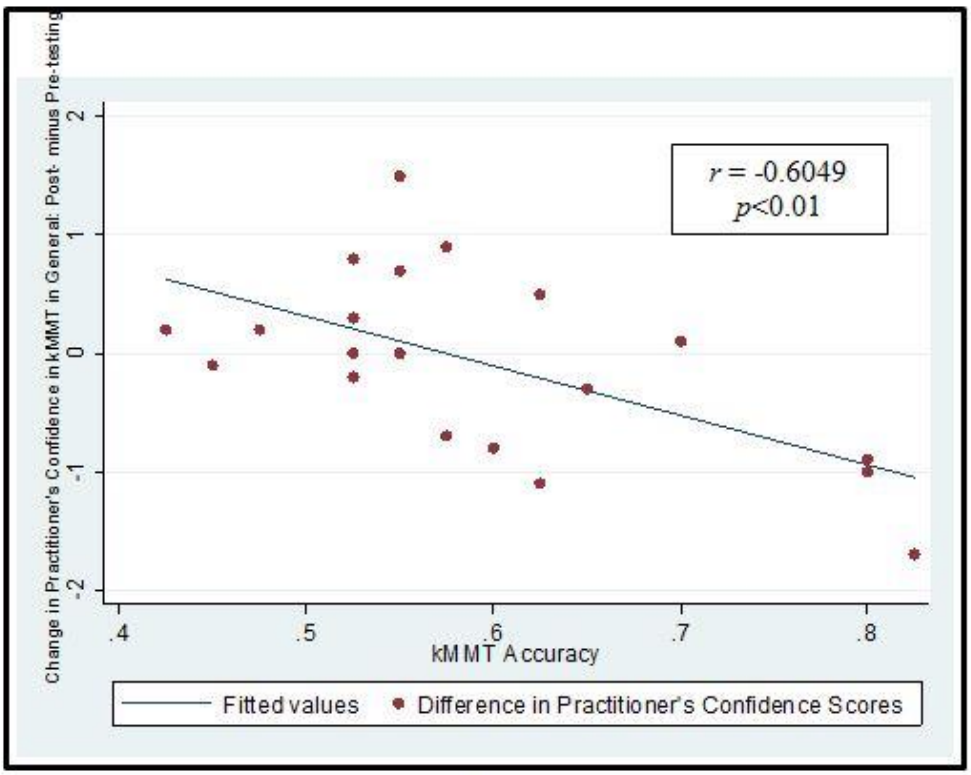
(2) their Confidence in their paired Practitioner, and

(3) their Confidence in their paired Practitioner's kMMT ability.

Conceiving that it may be the *change* in these ratings that may have some relationship to kMMT accuracy, I calculated the differences between the post- and pre-testing ratings, and compared them to kMMT accuracy. See Table 3.11. kMMT accuracy seemed to be modestly, but significantly, negatively correlated to the change in Practitioner Confidence in kMMT in General (Post– minus Pre–testing; $r = -0.6049$; $p<0.01$), but to none of the other changes in Confidence ratings. See Figure 3.5. Furthermore, there was no other significant relationship detected between kMMT accuracy and *any* other Confidence score (see Appendix Table B.3.3).

Finally, looking to see how Practitioner Subjective State Anxiety influenced kMMT accuracy, I created a scatterplot, which showed no obvious relationship. Further analysis revealed a correlation coefficient which was insignificant ($r = 0.0737$; $p= 0.76$). See Figure 3.6.

FIGURE 3.5 – Scatterplot for correlation.



(F)

FIGURE 3.6 – Correlation among kMMT accuracy and Practitioner's subjective anxiety rating.

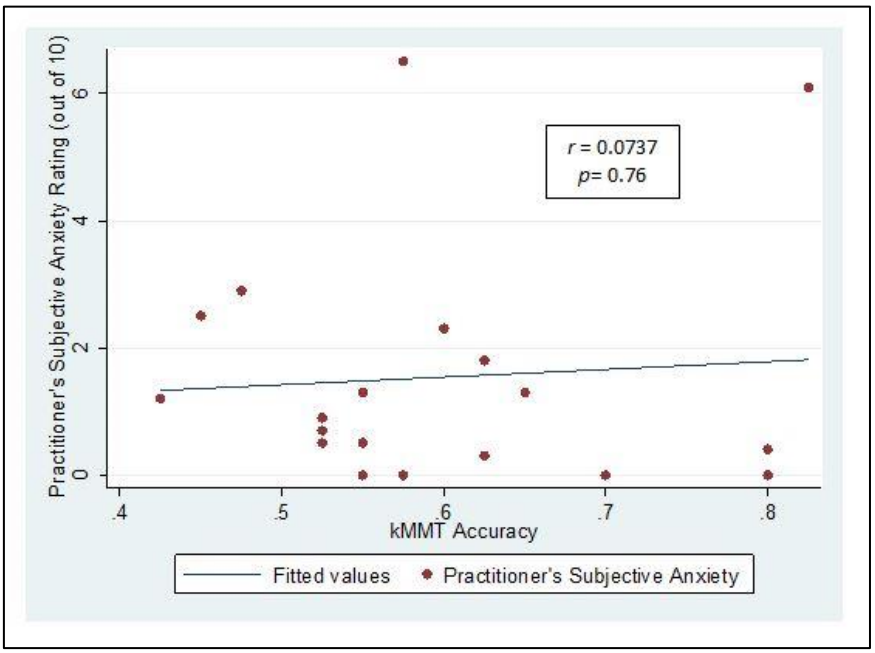


TABLE 3.11 – The change in confidence ratings and correlations (*r; with p-values)* among kMMT accuracy and participant confidence scores. *p*(2-tailed)<0.05

	Mean (95% CI)	***p* -value** **(Compared to Zero)**	**Correlation Coefficients (r & *p-values*)**				
			1.	**2.**	**3.**	**4.**	**5.**
1. The Difference in Practitioner's Confidence in their OWN kMMT Ability: Post - Pre	-0.175 (-0.629 to 0.279)	0.43	1.000				
2. The Difference in Practitioner's Confidence in kMMT in General: Post - Pre	-0.080 (-0.447 to 0.287)	0.65	0.3088 *0.19*	1.000			
3. The Difference in Test Patient's Confidence in kMMT in General: Post - Pre	0.955 (-0.309 to 2.219)	0.13	-0.0142 *0.95*	0.1213 *0.61*	1.000		
4. The Difference in Test Patient's Confidence in their Paired Practitioner: Post - Pre	0.065 (-1.335 to 1.465)	0.92	0.0958 *0.69*	0.2549 *0.28*	0.5117 *0.02*	1.000	
5. The Difference in Test Patient's Confidence in their Paired Practitioner's kMMT Ability: Post - Pre	-1.410 (-5.979 to 3.159)	0.53	0.0796 *0.74*	-0.0636 *0.79*	0.2007 *0.40*	0.1737 *0.46*	1.000
6. kMMT Accuracy			-0.2513 *0.29*	-0.6049 *<0.01*	0.1441 *0.54*	-0.2606 *0.27*	0.3546 *0.13*

kMMT, kinesiology-style Manual Muscle Testing; = kMMT Accuracy correlations; = Correlation (r) which reached significance (p<0.05).

3.5 Discussion

3.5.1 Statement of Principal Findings

This study successfully replicated the results of Study 1, finding that kMMT can be used to distinguish lies from truth with an accuracy above that of Intuition or Chance. Also the mean accuracies achieved in this study fell within or very close to the 95% CIs of Study I, and the mean accuracies of Study 1 (see page 78) fell within or very close to the CIs of this study, indicating that the results of these two studies were remarkably similar. Furthermore, there again seems to be no correlations between kMMT accuracy and Intuition accuracy, or between kMMT accuracy for True vs. False Statements. Furthermore, kMMT accuracy was not affected by Block, which may mean that fatigue and/or learning appear not to contribute.

A sensitivity of 0.503 (95% CI 0.421 - 0.584) indicated that only half the Lies were detected, while a specificity of 0.685 (95% CI 0.616 - 0.754) suggests that 69% of the Truths were detected. These statistics were quite different to those achieved in Study 1 (see page 78). However, interestingly, in both studies, a higher proportion of Truths were detected compared to Lies, which may suggest that, when using kMMT, Truths are easier to detect than Lies.

In this study, prevalence of Lies was fixed at 0.50, compared to Study I, where the prevalence of Lies varied. From the mean PPV, this study found that if the kMMT result went "weak," there was a 61% chance that the statement was actually a Lie, and from the NPV, if the kMMT result was "strong," there's a 58% chance that the statements was True. These findings were distinctly different from those Pairs tweezed out of Study 1 whose prevalence of Lies was exactly 0.50 (n=9; see Appendix Table B.2.8). Once again, since the prevalence

of Lies is not actually known in a true clinical setting, the predictive values reported here should not be applied universally.[106]

Because this study was powered to evaluate kMMT overall fraction correct (n=20), I am cautious about assessing the credibility of any subgroup analysis, especially with the small sample sizes of some of the subgroups.[142] However, for completeness, I discuss them below.

The present study explored three additional factors that Study 1 did not consider: (1) The effect of Practitioner's Subjective Anxiety on kMMT accuracy, (2) the effect of using non-kMMT-naïve TPs, and (3) the effect of using participants that knew each other. None of these factors made a significant difference to kMMT accuracy.

Overall, analogous to Study 1, this study failed to find any consistently significant influencers of kMMT, even the influencer that Study 1 found[ii] proved to lack significance in this study. That is, the following characteristics failed to be related to kMMT accuracy:

- Practitioner profession
- Practitioner's number of years in practice
- Practitioner's number of years practising kMMT
- Practitioner's usual number of hours/day using kMMT
- Practitioner's kMMT technique(s) used
- Practitioner's current practising status
- Practitioner's self-ranked kMMT-expertise
- Practitioner age
- TP age

[ii] Study 1 found that Pairs with male TPs achieved a higher mean accuracy than those with female TPs.

- Practitioner's gender
- TP's gender
- Pair's sameness of gender
- TP's handedness
- Which arm the Practitioner used during testing
- If the TP reporting guessing the paradigm
- If the TP wore glasses during testing
- If the TP was kMMT-naïve
- If the TP knew their paired practitioner
- Any TP confidence rating
- All but one (1) Practitioner confidence rating
- Practitioner's subjective anxiety, or
- Block of testing (Late vs. Middle vs. Early in the testing)

This failure to detect any factor that consistently impacts kMMT accuracy is curious indeed. I can only speculate that no relationships between these variables actually exist, or that the measures I used to detect them lack sufficient sensitivity or the study lack sufficient power.

3.5.2 Strengths and Limitations

Many of the strengths and limitations of Study 1 also apply to this study (see page 97). However, some of the factors that were a source of limitation in Study 1 were modified to improve this study. For example, the sample of TPs was more heterogeneous in that also included were those that were not naïve to kMMT, as were those that knew their paired Practitioner. These changes did not seem to affect the study outcome, and yet broadened the generalisability.

Other limitations of Study 1 could not be improved. For instance, while every effort was made to keep the testing environments realistic, the nature of the research setting still could not exactly replicate a true clinical setting. The other primary limitation common to both studies is that their results cannot be generalised to other applications of kMMT. While kMMT may be useful in distinguishing false statements from true statements, kMMT may not be useful for any other application, such as detecting food allergy, the need for nutritional supplementation, or foetal gender, despite being used to detect such targets in clinical practice.[34, 90, 94, 143] Another limitation of this study is the smaller sample size may have underpowered subgroup analyses, since no significant relationships were detected once again.

One of the clear strengths of this study is that a simpler methodology achieved similar results. Other strengths shared by other studies are the choice of reference standard (i.e. a "gold" standard) and a high degree of blinding. In this study, the Practitioners were blind throughout, which may more closely emulate a true clinical setting. Also, while some TPs reported guessing the paradigm and therefore were (or during the course of testing, became) possibly not blind to expectations, TP's blindness did not seem to influence kMMT accuracy. In addition, in this study TPs were again not blind to the verity of the statements they spoke, which also does not necessarily match a true clinical situation.

3.5.3 Possible Explanations of Results

Since the results obtained in this study were similar to that of Study 1 (see page 75), a number of explanations are in order. Firstly, despite Study 1 being replicated without randomly blinding the Practitioner and without solely naïve TPs, the similarity in results suggests that blinding in kMMT is less important than was previously supposed.

The one significant correlation detected in this study was between kMMT accuracy and the change in Practitioner's Confidence in kMMT in General. This correlation was moderate and negative, which oddly translates to this: Practitioners being more confident after testing than before was related to a lower kMMT accuracy. Since in practice, this makes little sense, a likely explanation of this significant correlation is chance, and at minimum, further examination is warranted before any genuine relationship can be considered.[144]

Also, it was suspected that the level of anxiety that a Practitioner experienced prior to testing might have a deleterious impact on being able to perform kMMT accurately.[145, 146] However, this was not the case. Reasons for this could be that anxiety does not actually affect kMMT testing, or that the 10cm VAS used was not an adequate measure of subjective state anxiety. Another reason may be that it is not *anxiety* per se that might be an influencer but rather *stress* or a *stress response*.

3.5.4 Implications for clinical practice

The implications of these results for clinicians are the same as those described in Study 1 (Chapter 2, page 103). Also, the successful replication of Study 1 weakens the argument of those detractors who suggest that kMMT is nonsense and lump it in together with fortune-telling, divination, dowsing and other unsubstantiated phenomenon.

3.5.5 Unanswered questions and future research

The results of this study, naturally lead to further queries. Firstly, since blinding the Practitioners did not seem to influence kMMT accuracy, I wonder if the same outcomes can be achieved if the TPs are blind to the verity of statements they were speaking. This question is important to address in future research since in practice, during the course of a kMMT

session, TPs are often kept in the dark about what target condition(s) the kMMT Practitioner is assessing. Furthermore, in essence, many times it is *nonconscious beliefs* that are purportedly being uncovered with kMMT.[24] The concept of testing for nonconscious beliefs at this point in time leads to many significant methodological conundrums, not to mention the ethical considerations. However, researchers may wish to explore this avenue in the future.

Since these two studies failed to detect any factors that consistently affect kMMT performance, future research may also want to delve into other possible influencers. It may be necessary to employ non-subjective (i.e. not self-report, and more objective) measures of such qualities as confidence, trust, rapport or other characteristics of the doctor-patient dyad.

Following on from this, I noticed that the ranges of kMMT accuracy scores over both studies were relatively wide. In Study 1, kMMT accuracies ranged from 0.400 to 0.917, a width of over 50 points, and similarly, the range in Study 2 was 0.425 to 0.825, a 40-point difference. Prospective researchers may want to study further those practitioners that achieved high scores (e.g. >0.80) and compare them to those that scored low (e.g. <0.50). In addition, if commonalities are noticed in high-scoring practitioners, it would be interesting to attempt to teach these to low-scoring practitioners to see if their scores could improve.

Another curious outcome of this research is that Practitioner anxiety did not affect kMMT accuracy. Future studies may want to use a more standard measure of anxiety, like the State-Trait Anxiety Inventory (STAI), with both the Practitioners and the TPs. I suggest also to measure TPs' anxiety because a common, yet unsubstantiated, explanation of kMMT is that lies (a form of stress[147]) cause the body to react by weakening muscles, such as the indicator muscle. Therefore, it would be interesting to assess other psychophysiological measures of

stress or anxiety[iii] of TPs during the testing (e.g. heart rate, heart rate variability, skin conductance, even EEG or fMRI), and correlate them with the speaking of lies during kMMT. Moreover, if a stress response caused by lying results in diminished muscular strength, then the same result may be obtained if other tests of muscular strength are employed. Of special interest may be those tests of muscular strength that are objective, and free of an assessor's subjectivity, such as grip-strength testing.

Finally, it also would be interesting if future research would vary other factors which I kept constant in these 2 studies. For instance, perhaps if the valence of stimuli were modified to be emotionally arousing (negatively or positively) this might evoke a stronger stress response, and if stress is indeed a governing factor, kMMT accuracy might improve (as might Intuition accuracy as well) if more stress was induced.

3.6 Summary

This study successfully replicated Study 1 by again finding that kMMT can be used with significant accuracy to distinguish lies from truths, compared to both Intuition and Chance. Moreover, this study further supports the concept that a simple yet robust methodology for assessing the value of kMMT as a diagnostic tool can be developed and implemented effectively. Comparable to Study 1, no factors were identified that seemed to consistently influence kMMT accuracy. The strengths of this study were also parallel to Study 1 : (1) a high degree of blinding, (2) the heterogeneity of the samples, (3) the choice of a clear target condition, and (4) the choice of a "gold standard" as the reference standard. Finally, also

[iii] While stress and anxiety are distinct conditions in psychological terms, they may be related. For instance, experientially it is difficult to feel anxiety without some element of psychological stress. [Cox RH. Sport psychology: Concepts and applications. 6th ed. New York: McGraw-Hill; 2006.]

similar to Study 1, the main limitation of this study is its lack of generalisability to other applications of kMMT.

3.7 Chapter 3 – List of Tables and Figures

3.7.1 Tables

3.7.2 Figures

CHAPTER 4

Study 3 – Grip Strength Dynamometry for Lie Detection

"The most accurate diagnosing tool you can have is in your office—YOUR PATIENT, with Innate intelligence the body language combined with muscle testing."

George J. Goodheart, Jr. (Founder, Applied Kinesiology)

CHAPTER 4 : STUDY 3 – GRIP STRENGTH DYNAMOMETRY FOR LIE DETECTION

4.1 ABSTRACT

Research Objectives: To investigate if dynamometric muscle testing (DMT) could be used to distinguish Lies from Truth.

Methods: A prospective study of diagnostic test accuracy was carried out. Twenty Test Patients (TPs), aged 18-65 years, with fully functioning and painfree hands, were recruited. After viewing a picture on a computer screen, TPs were instructed to speak a specific statement about the picture and then squeeze a dynamometer for 5 seconds, giving a maximum effort each time. The examiner recorded the grip strength (to the nearest 1 kg) directly into the computer, which advanced the screen to the next picture/statement. Testing proceeded in this manner until 20 DMTs were performed, 10 by each hand.

Results: The mean grip strength after True statements was found to be 24.9 kg (95% CI 20.3 to 29.6), and after False statements, 24.8 (95% CI 20.2 to 29.5), which were not statistically different (p=0.61). No significant correlations were detected between difference in grip strength (False – True) and age, gender, confidence in MMT (pre-testing or post-testing), or change in confidence scores. Also compared were mean grip strengths by block and were found to be stable throughout testing

Summary: DMT via hand-held grip strength dynamometry failed to distinguish Lies from Truth. These results seem to suggest that strength, as measured by DMT, is not impacted by deceit. However, some other yet undetermined quality may allow kMMT to accurately make

this distinction unlike DMT. A limitation of this study is it is not generalisable to other applications of muscle testing or other target conditions.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; muscle contraction; lie detection; deception; lying; grip strength; dynamometry.

4.2 Introduction

The previous two studies in this series have found that kinesiology-style manual muscle testing (kMMT) is better than Chance or Intuition at distinguishing Lies from Truth. One possible explanation of these results is that lying, a known stress, causes specific physiological changes,[148, 149 150] and muscle weakening may be one such change. If this hypothesis is true, then other types of muscle strength testing might also be useful at distinguishing lies from truth.

It is widely thought that kMMT lacks sufficient subjectivity to be a valid test.[151] If practising clinicians are to have confidence in kMMT, it must be compared to and shown to agree with a more objective measure of muscle strength. A quantitative, instrumented alternative to manual muscle testing (MMT), hand-held grip strength dynamometry (see Figure 4.1) has been shown to be an accurate, reliable and objective test of muscle strength, which correlates well with other forms of MMT.[56, 152-154] Dynamometric muscle testing (DMT) quantifies MMT by recording the peak force generated by a muscle or a group of muscles when loaded in tension or compression.[56]

Previous studies have attempted to use grip strength dynamometry to detect conditions other than musculoskeletal. Radin successfully used grip strength to distinguish refined sugar (purportedly, a toxic substance) from sand (hypothetically inert or nontoxic).[155] However, three replication studies that followed failed to support his findings.[156-158]

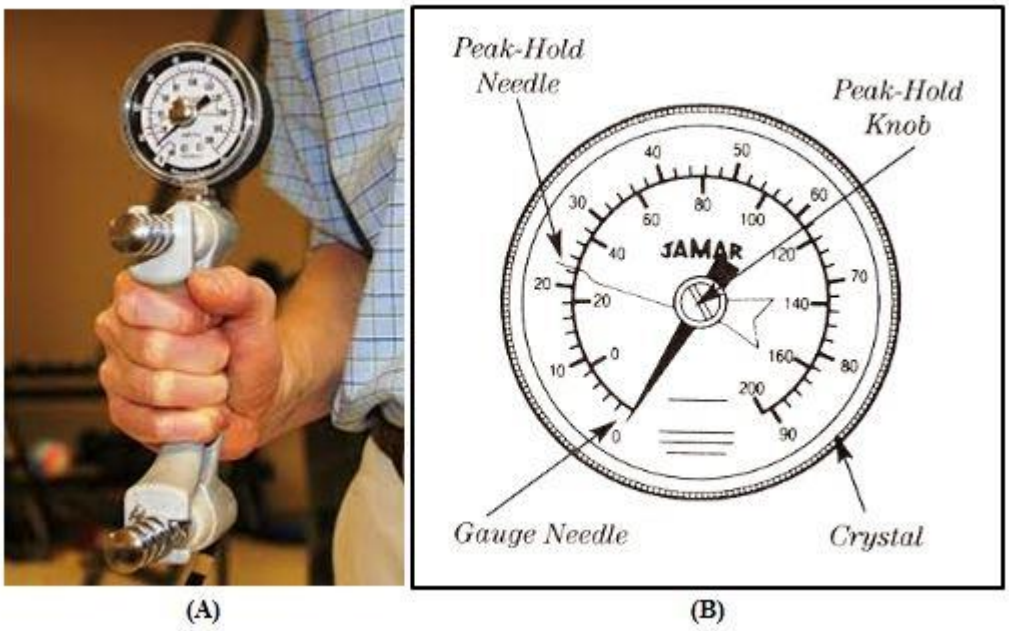
Notwithstanding these discouraging results, it is speculated that DMT might be a useful alternative to kMMT for detecting deceit. With the intent of enhancing objectivity, the aim of this study was to investigate if DMT could be used to distinguish Lies from Truth.

4.3 Methods

Reported here is a prospective study of diagnostic test accuracy. No participant was assessed prior to enrolment. This protocol received ethics committee approval by the Oxford Tropical Research Ethics Committee (OxTREC; Approval #41-10) and the Parker University Institutional Review Board for Human Subjects (Approval # R19_10). Also, this study protocol was registered with two clinical trials registries: the Australian New Zealand Clinical Trials Registry (ANZCTR; www.anzctr.org.au), and US-based ClinicalTrials.gov.

Written informed consent was obtained from all participants, and all other tenets of the Declaration of Helsinki were upheld. This paper was written in accordance with the Standards for the Reporting of Diagnostic Test Accuracy Studies (STARD) guidelines (see Appendix D, page 374, for the STARD Checklist).[47, 66, 99]

FIGURE 4.1 – Grip strength dynamometer. (A) Example of a grip strength dynamometer. (B) Face of a grip strength dynamometer.



4.3.1 Participants and Setting

Unlike the other studies in this series, this study recruited only one group of participants: Test Patients (TPs; n=20), who were aged 18-65 years, had fully functioning and painfree hands, and were fluent in English. Volunteers were excluded if they had visual, auditory or speech impairment. In addition, kMMT-naïve as well as non-kMMT-naïve TPs were enrolled. Recruitment was by direct contact, social media and word of mouth. All recruitment took place in America, in the states of Texas and New York.

Each participant was given a Participant Information Sheet (PIS) and gave written informed consent. They also completed the same pre- and post-testing questionnaires used in Studies 1 and 2, omitting questions referring to a Practitioner (See Appendix A, page 245). In the post-testing questionnaire, participants were asked if they noticed anything different in their tests following True statements compared to False statements. This question was included to ascertain if they guessed the aim of the study, which was to investigate if grip strength can be used to distinguish Lies from Truth. In this study, non-kMMT-naïve TPs were enrolled in addition to kMMT-naïve TPs. And it was likely that those with prior kMMT experience were aware of the paradigm that kMMT following False statements resulted in a "weak" outcome, and kMMT following a True statement resulted in a "strong" outcome. Therefore, it was necessary to track on both the kMMT-naivety of the TPs and if they noticed a difference or guessed the paradigm.

4.3.2 Test Methods

The target condition (i.e. deceit) and reference standard (i.e. the verity of the spoken statement) remained consistent with Studies 1 and 2. However, the index test used to detect deceit was hand-held grip strength DMT. Each participant performed 20 DMTs after

speaking an instructed statement out loud, 10 with their dominant hand and 10 with their non-dominant hand, broken up into blocks of five: 5 dominant, 5 non-dominant, 5 dominant, 5 non-dominant.

The stimuli presented were selected from the same database of 100 affect-neutral pictures/statements used in Studies 1 and 2. DirectRT™ Research Software (Empirisoft Corporation, New York, NY) was programmed to randomly present a unique sequence of stimuli for each participant, while randomizing the verity of the statements (i.e. True or False), and keeping the prevalence of False statements constant at 0.50.

4.3.2.1 Grip Strength Dynamometry

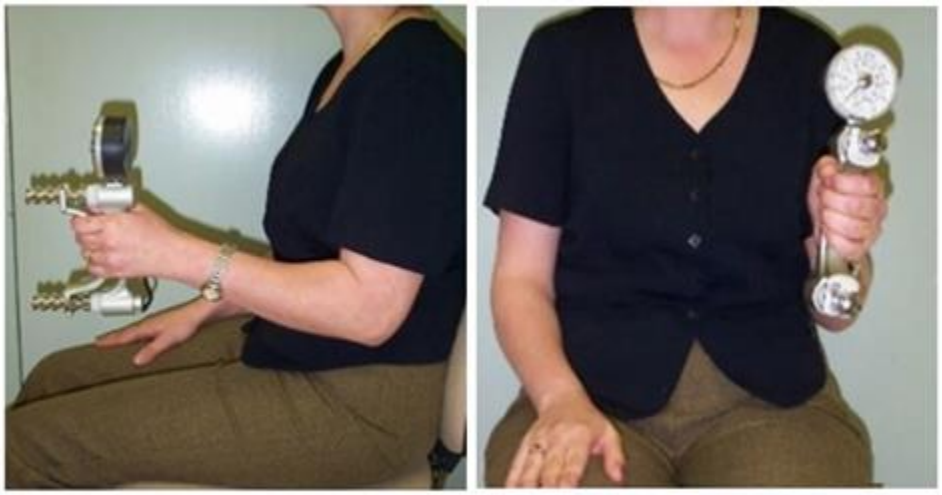
All DMT was performed using the same factory calibrated hydraulic JAMAR (Model J00105, Lafayette, Indiana, USA) analogue hand-grip dynamometer, found to be an accurate[159] and reliable[160] measure of grip strength. In addition, DMT correlates well with other forms of muscle testing,[56] and its intra-subject test–retest variability has been found to be small.[161] TPs were instructed to squeeze the dynamometer for 5 seconds, giving a maximum effort each time. They could rest as needed. The examiner read the kilograms scale on the dial face, and after recording the result, reset the peak-hold needle to zero, ready for the next effort. Grip strength was measured to the nearest 1kg.

4.3.2.2 Procedures

The TP was seated comfortably in front of a computer and held the dynamometer vertically in his hand, elbow at his side and bent to 90 degrees, and forearm and wrist in neutral (i.e. palm facing medially; see Figure 4.2). The investigator (AJ) was seated in front and to the side of the TP, positioned to that she could read the dial of the dynamometer (see Figure 4.1.B), which was facing away from the TP, and also not see the computer screen. For the

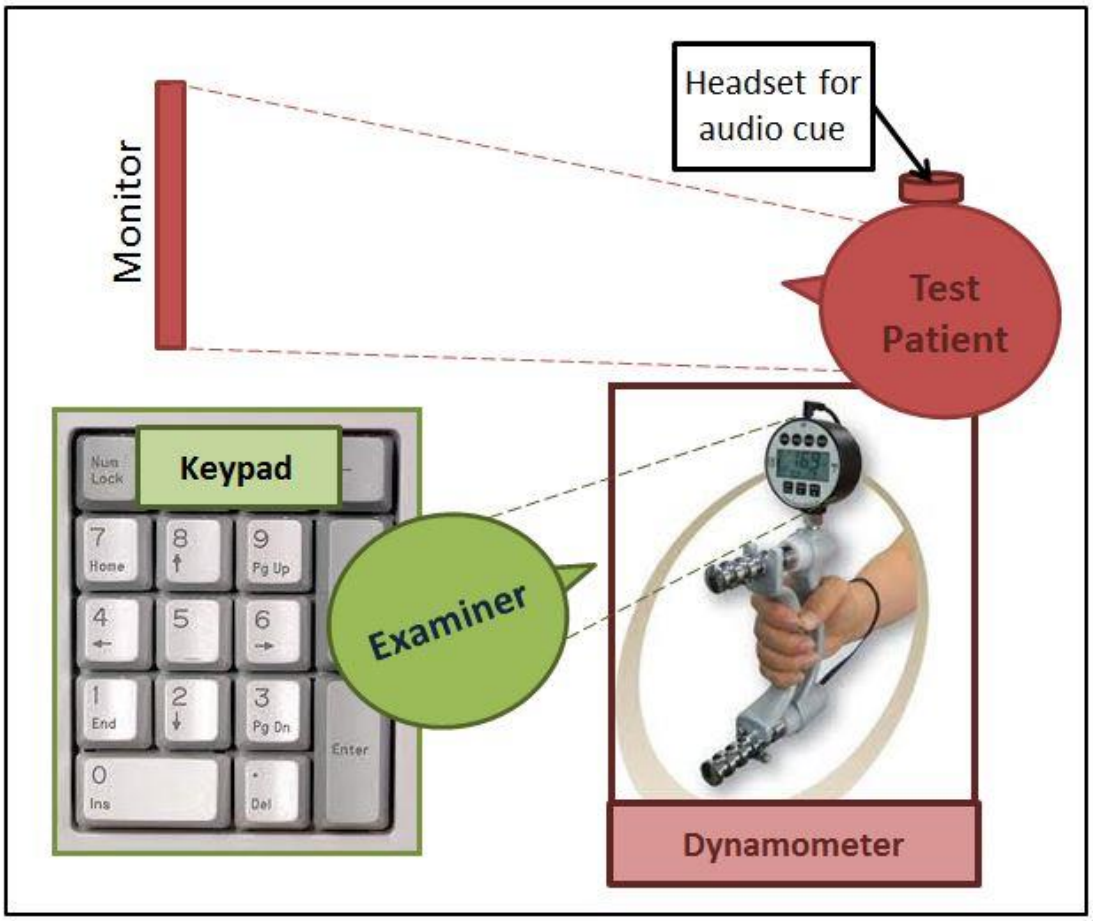
testing scenario layout, see Figure 4.3. One repetition of DMT was similar to one repetition of kMMT in previous studies: (1) TP viewed a picture, (2) TP was instructed (via an earpiece) what to say in relation to the picture, (3) TP took the DMT position, (4) while viewing the picture, TP spoke the instructed statement, (5) TP immediately performed the DMT, and (6) the examiner recorded the grip strength result directly into the computer, which advanced the screen to the next picture/statement. Testing proceeded in this manner until 2 blocks of 5 DMTs were performed by each hand.

FIGURE 4.2 - DMT testing position example. (A) Elbow flexed to approximately 90^{o}, (B) Elbow at side, gauge facing away from TP, toward assessor.



(A) (B)

FIGURE 4.3 – Testing scenario layout.



4.3.3 Statistical Methods

Mean grip strengths following False statements and True statements were calculated for each TP and are reported with their 95% confidence intervals. Then these means were compared using a paired t-test. The same analyses were made stratified by gender, stratified by dominant and non-dominant hand, stratified by kMMT-naivety and stratified by reporting having guessed the paradigm. In addition, the mean difference in grip strengths ($Mean_{True} - Mean_{False}$) was calculated and compared to 0.0 (i.e. no difference) using a paired t-test. Then, a comparison of group means was conducted with linear regression models using as covariates the participant characteristics of age and self-reported confidence scores. Finally,

correlation analyses were made between mean Grip Strengths and other participant characteristics.

Statistical advice was sought during the design phase, after piloting, and before data analysis. All data were analyzed using Stata/IC 12.1 (StataCorp LP, College Station, Texas), specifically the commands "*ttest*" and "*pwcorr*."

4.4 Results

4.4.1 Participants

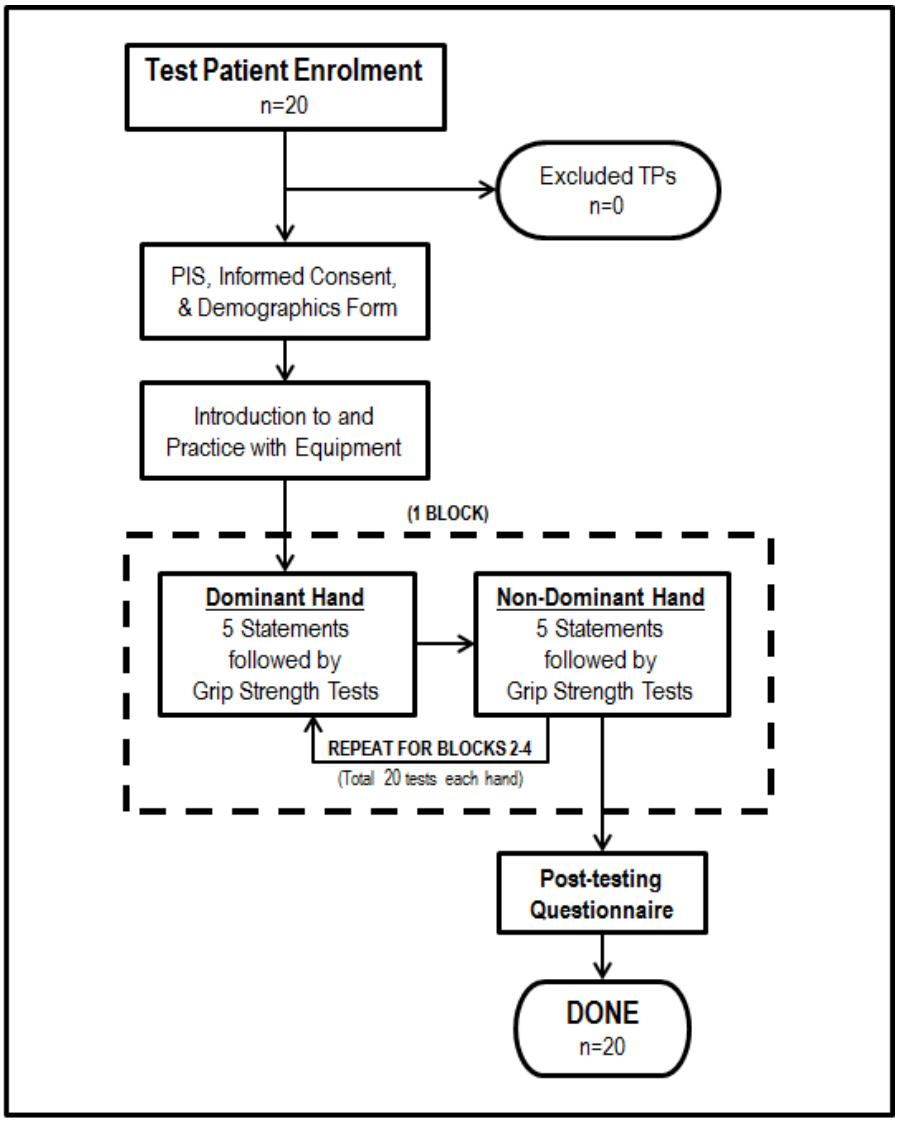
Twenty TPs were enrolled between June and August 2011: 11 males and 9 females. The mean (SD) age was 48.4 (12.1) years. Seventeen reported being right-hand dominant and 3 left-hand dominant, and 14 reported being kMMT-naïve and 6 reported having had some prior experience with kMMT. For a summary of participant demographics, see Table 4.1. Also, see Figure 4.4 for the Participant Flow Diagram.

TABLE 4.1 – Demographics of participants.

	Participants (n=20)
Gender (M : F)	11:9
Mean age (SD)	48.4 (12.1)
Dominant Hand (R : L)	17:3
Prior kMMT Experience (kMMT-naïve : non-naïve)	14:6
Mean degree of confidence in kMMT (pre-testing)† (SD)	5.9 (2.0)

kMMT, kinesiology-style Manual Muscle Testing; SD, Standard Deviation; M, Male; F, Female; R, Right; L, Left;
†Measured using a 10cm Visual Analog Scale, from 0="None" to 10="Most Ever"

FIGURE 4.4 - Participant Flow Diagram : Study 3 (Grip Strength).



TP, Test Patient

4.4.2 Test Results

Participants took between 5 and 15 minutes to complete their participation, all completed all DMT in full and there were no adverse events reported from any testing. Histograms of grip strength scores showed that the data are normally distributed (see Appendix Figure B.4.1), so parametric statistics have been applied.

The mean grip strength after True statements was found to be 24.9 kg (95% CI 20.3 to 29.6), and after False statements, 24.8 (95% CI 20.2 to 29.5), which was not statistically different (p=0.61). Also calculated for each participant was the difference in mean grip strengths between True and False statements (Difference = $\text{True}_{\text{Mean Grip Strength}} - \text{False}_{\text{Mean Grip Strength}}$), and the mean difference was found to be 0.1 (95% CI -0.4 to 0.6), which was no different from 0.0 (p=0.61). See Table 4.2.A and Appendix Table B.4.1.A.

I also looked at the dominant and the non-dominant hands independently. Using the data for the dominant hand only, the mean grip strength after True statements was found to be 23.9 kg (95% CI 19.3 to 28.5), and after False statements, 23.5 (95% CI 18.9 to 28.2), which was not statistically different (p=0.21). For the non-dominant hand only, the mean grip strength after True statements was found to be 26.0 kg (95% CI 21.3 to 30.7), and after False statements, 26.1 (95% CI 21.2 to 31.0), which was not statistically different (p=0.81). See Table 4.2.B and Appendix Table B.4.1.B.

Next I looked at different groups separately: Males vs. Females, kMMT-naïve vs. non-kMMT-naïve, and those TPs who reported guessing the paradigm vs. those who did not. For males (n=11), the mean grip strengths after True and False statements were identical: both 31.3 kg (95% CI for False statements, 26.3 to 36.3, and for True statements, 26.2 to 36.4), and therefore, not statistically different (p=0.98). Whereas for females (n=9), the mean grip strength after False statements was 17.2 kg (95% CI 21.3 to 30.7), and for True statements 16.9 kg (95% CI 12.4 to 21.4), which were not statistically different (p=0.43). For the kMMT-naïve subgroup (n=14), the

TABLE 4.2 – Comparison of mean grip strengths (kg) for False vs. True statements. (A) Combined data for both hands, and the mean difference, (B) Dominant and non-dominant hands separately.

(A)	*n*	Grip Strength (kg) Mean	95% CI	p-value
False Statements	20	24.8	20.2 to 29.5	0.61
True Statements	20	24.9	20.3 to 29.6	
Mean Difference*	20	0.1	-0.4 to 0.6	0.61†

kg, Kilogram; CI, Confidence Interval.
* The Mean of (Grip Strength after True Statements - Grip Strength after False Statements)
† Mean Difference compared to zero (0.0).

(B)		Grip Strength (kg) Dominant Hand			Non-Dominant Hand		
	n	Mean	95% CI	p-value	Mea	95% CI	p-value
False Statements	20	23.5	18.9 to 28.2	0.21	##	21.2 to 31.0	0.81
True Statements	20	23.9	19.3 to 28.5		##	21.3 to 30.7	

kg, Kilogram; CI, Confidence Interval.

mean grip strength after False statements was 25.9 kg (95% CI 19.6 to 32.2), and for True statements 25.8 kg (95% CI 19.4 to 32.2), while for the non-kMMT-naïve subgroup (n=6), the mean grip strength after False statements was 22.3 kg (95% CI 14.7 to 29.9), and for True statements 22.9 kg (95% CI 16.1 to 29.8), which were both not statistically different (p=0.74 and p=0.11, respectively). For those who did not report guessing the paradigm (n=12), the mean grip strength after False statements was 26.6 kg (95% CI 20.1 to 33.0) and for True statements 26.1 kg (95% CI 19.6 to 32.6), which were not statistically different (p=0.09). However, for those who reported guessing the paradigm (n=8), the mean grip strength difference reached significance (p=0.02): 22.2 kg (95% CI 14.1 to 30.3) after False statements and 23.2 kg (95% CI 15.1 to 31.3) after True statements. See Table 4.3.

Also compared were mean grip strengths by block which were found to be consistent throughout testing (see Figure 4.5).Finally, no significant correlations were detected between

difference in grip strength (False – True) and age, gender, confidence in kMMT (pre-testing or post-testing), or change in confidence scores (see Table 4.4).

TABLE 4.3 – Comparison of mean grip strengths (kg) for False vs. True statements. By gender; (B) By naivety to kMMT; and (C) By reported guessing the paradigm.

(A)	Grip Strength (kg)					
	Males (n=11)			**Females** (n=9)		
	Mean	**95% CI**	**p-value**	**Mean**	**95% CI**	**p-value**
False Statements	31.3	26.3 to 36.3	0.98	17.2	12.4 to 21.9	0.43
True Statements	31.3	26.2 to 36.4		16.9	12.4 to 21.4	

kg, kilogram; CI, Confidence Interval.

(B)		Grip Strength (kg)					
		Naïve to kMMT (n=14)			**Not Naïve to kMMT** (n=6)		
	n	**Mean**	**95% CI**	**p-value**	**Mean**	**95% CI**	**p-value**
False Statements	20	25.9	19.6 to 32.2	0.74	22.3	14.7 to 29.9	0.11
True Statements	20	25.8	19.4 to 32.2		22.9	16.1 to 29.8	

kg, kilogram; CI, Confidence Interval.

(C)		Grip Strength (kg)					
		Did not Report Guessing the Paradigm (n=12)			**Reported Guessing the Paradigm** (n=8)		
	n	**Mean**	**95% CI**	**p-value**	**Mean**	**95% CI**	**p-value**
False Statements	20	26.6	20.1 to 33.0	0.09	22.2	14.1 to 30.3	**0.02***
True Statements	20	26.1	19.6 to 32.6		23.2	15.1 to 31.3	

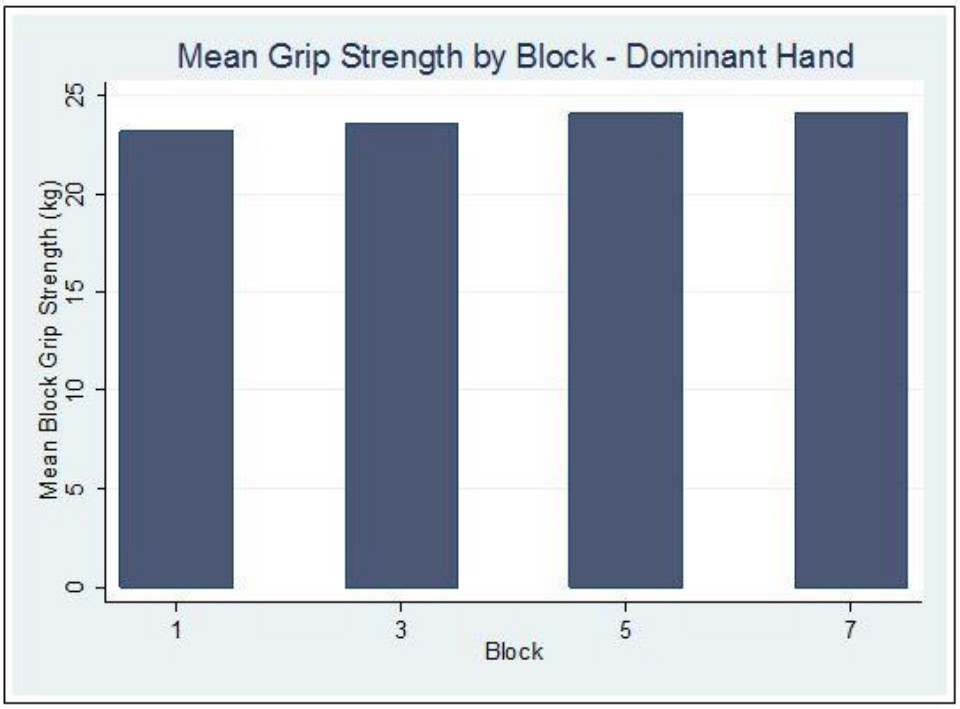
kg, kilogram; CI, Confidence Interval; * Reached significance.

TABLE 4.4 – Correlations among grip strengths and other participant characteristics.

	1.	2.	3.	4.	5.	6.
1. Age	1.0000					
2. Confidence in MMT (Pre-testing) *p-value*	-0.0142 *0.95*	1.0000				
3. Confidence in MMT (Post-testing) *p-values*	0.1489 *0.53*	**0.9219** ***<0.01****	1.0000			
4. Difference in Confidence in MMT (Post- minus Pre-testing) *p-values*	0.4182 *0.07*	0.0036 *0.99*	0.3907 *0.09*	1.0000		
5. Grip Strength (kg) after True Statements *p-values*	0.0315 *0.90*	0.0348 *0.88*	-0.1639 *0.49*	**-0.5057** ***0.02****	1.0000	
6. Grip Strength (kg) after False Statements *p-values*	0.0461 *0.85*	0.0131 *0.96*	-0.1753 *0.46*	**-0.4834** ***0.03****	**0.9941** ***<0.01****	1.0000
7. Difference in Mean Grip Strengths (kg): False minus True *p-values*	-0.1369 *0.56*	0.1975 *0.40*	0.118 *0.62*	-0.1645 *0.49*	-0.0266 *0.91*	-0.1347 *0.57*

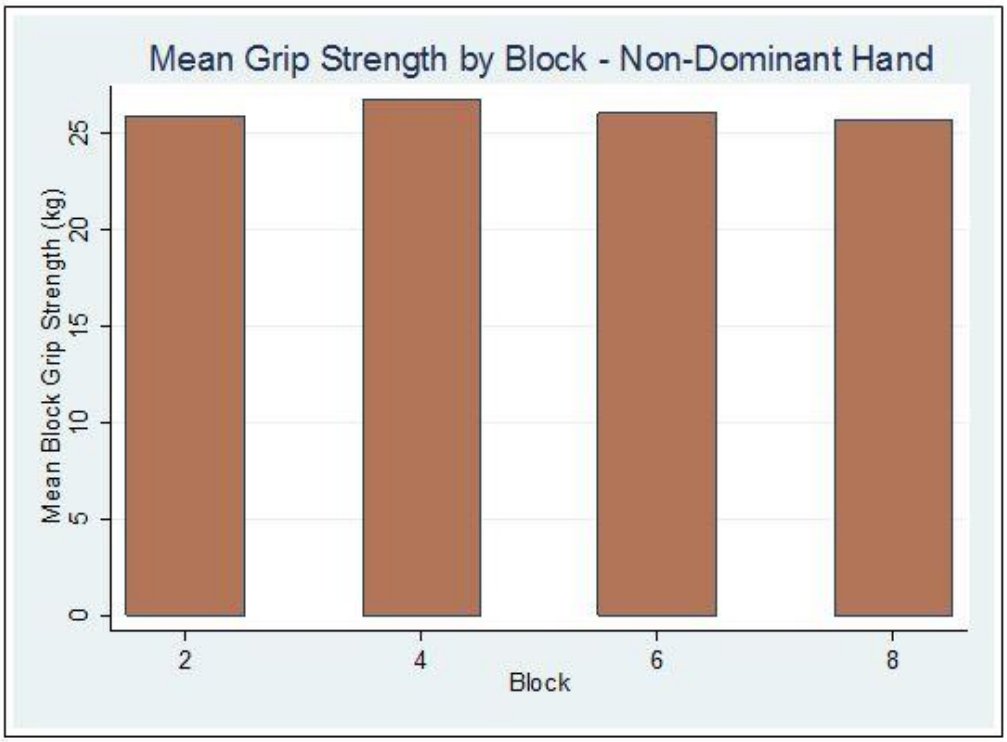
MMT, Manual Muscle Testing; kg, kilogram; * Significance reached.

FIGURE 4.5 – Mean grip strengths by Block. (A) Dominant hand, (B) Non-dominant hand.



(A)

FIGURE 4.5 (con't.)



(B)

4.5 Discussion

4.5.1 Statement of Principal Findings

Unlike previous studies in this series, the current study failed to demonstrate that deceit can be detected by muscle testing, in this case DMT using grip strength dynamometry. This seems to imply that the kMMT practitioner is an integral part of the practitioner-patient complex, and cannot be removed. Another interesting finding is that the mean grip strengths found in this study were lower that accepted normative values.[162, 163]

Comparing these DMT results to those of kMMT may be inappropriate for a number of reasons. First of all, the DMT in this study tested the participants' grip strength, whereas the

prior studies in this series used kMMT on deltoid muscles, and it has not been established that the results of the kMMT studies can be generalised to testing muscles other than the deltoid. Secondly, while both types of muscle testing (DMT and kMMT) use isometric[i] muscle contractions (at least initially), DMT uses a patient's maximum effort, whereas kMMT uses submaximal force.[164]

4.5.2 Possible Explanations of Results

One might be tempted to attribute the lack of efficacy found in this study to a lack of sensitivity of the chosen testing instrument. However, this explanation is unlikely because previous research found that DMT was actually more discriminating than MMT in identifying small differences in muscle strength.[56, 161, 165] Another plausible explanation of these results may be that while DMT is measuring strength, deceit does not cause changes in strength, per se, but in some other quality (or qualities) perceptible by kMMT but not by DMT. More specifically, the strength of a muscle is the degree of force it can exert, and is dependent upon the size of the muscle and its nerve supply, but not dependent upon time or displacement.[166] However, time and displacement (or velocity) seem to be important factors in kMMT. [26, 27, 167] Therefore, strength (as assessed through DMT) may have been an incongruous index test to compare to kMMT, and perhaps another measure, such as power, might be more appropriate. A third explanation of these results might be that the practitioner is an integral component of the muscle testing dynamic, and therefore, if s/he is removed, the accuracy of the muscle test used to detect deceit becomes insignificant.

[i] *isometric contraction:* muscular contraction not accompanied by movement of the joint. (*Mosby's Medical Dictionary*, 8th edition. Oxford, UK: Elsevier, 2009.)

Numerous internal and external factors exist that may impact a person's ability to contract maximally, such as fatigue, pain, volition, motivation and even time of day.[168] It is unclear why the participants in this study scored generally lower than the standard reference values; however, it may be because of their high mean age (48.4 years, SD 12.1 years), or that all data collection occurred in America, or that this sample was particularly unhealthy. Because no information was collected on health status, fatigue, time of day or motivation level, it is difficult to speculate as to the cause of this marked difference.

Furthermore, since in this study grip strengths were found to be block-wise stable throughout testing, it is unlikely that learning, fatigue or other internal/external factors played a significant role. Lastly, the DMT in this study was patient-initiated while kMMT is usually tester-initiated. This may have had an influence as it seems that there are fundamental differences between the two.[169, 170]

4.5.3 Strengths and Limitations

A strength of this study is its rigorous design which was kept consistent with other studies in this series. In addition, since one examiner (AJ) performed all assessment, adherence was high. A more explicit strength was the duration of participation was suitable: given that maximum effort tests like DMT are limited by patient fatigue, and since the results show that fatigue was not influencing factor. In addition, the inclusion of participants with and without prior kMMT experience was a strength. While there was a significant difference between those participants who reported guessing the paradigm and those who did not, there was no significant difference found between kMMT-naïve and non-kMMT-naïve TPs. One limitation of this study is that its results are not generalisable to other applications of DMT, or to any MMT, or to other target conditions.

4.5.4 Implications for Clinical Practice

Because these results failed to confirm our null hypothesis that DMT may be useful for distinguishing Lies from Truth, the clinical implications of these results are limited: DMT is not useful for detecting deceit.

4.5.5 Unanswered Questions and Future Research

Future research may want to use other quantifiable measures to compare to kMMT, such as muscular power. Furthermore, the use of a digital / computerised dynamometer might give additional information about force, time and displacement, which our analog dynamometer could not.

4.6 Summary

DMT via hand-held grip strength dynamometry failed to distinguish Lies from Truth. One explanation of this might be that strength, as measured by DMT, is not impacted by deceit. For instance, perhaps it is not strength, but some other yet undetermined quality, that allows kMMT to accurately make this distinction but not DMT. A limitation of this study is it is not generalisable to other applications of muscle testing or other target conditions.

4.7 Chapter 4 – List of Tables and Figures

4.7.1 Tables

4.7.2 Figures

CHAPTER 5

Study 4 – Exploring the Variation in kMMT Accuracy through Repeatability and Reproducibility

"The only relevant test of the validity of a hypothesis is comparison of prediction with experience."

Milton Friedman

CHAPTER 5 : STUDY 4 – EXPLORING THE VARIATION IN KMMT ACCURACY THROUGH REPEATABILITY AND REPRODUCIBILITY

5.1 ABSTRACT

Research Objectives: To explore the variation in mean kMMT accuracy and whether this variation can be attributable to participant characteristics.

Methods: A prospective study of diagnostic test accuracy was carried out in a round-robin fashion, similar in methodology to Study 2 (see page 111). Sixteen Practitioners tested each of 7 Test Patients using 20 kMMTs broken into 2 blocks of 10 which alternated with 2 blocks of 10 Intuitions. Mean kMMT accuracies (as overall percent correct) were calculated for each unique pair. Reproducibility and repeatability was assessed using analyses of variance (ANOVA) and scatter and Bland-Altman plots.

Results: The mean kMMT accuracy (95% CI) was 0.616 (0.578 - 0.654), which was significantly different from both the mean Intuition accuracy, 0.507 (95% CI 0.484 - 0.530; $p<0.01$) and Chance ($p<0.01$). Visual inspection of scatterplots of mean kMMT accuracies by Practitioner and by TP suggest large variances among both subsets, and regression analysis revealed that kMMT accuracy could not be predicted by TP ($r = –0.14$; $p=0.19$), nor by Practitioner ($r=0.01$; $p=0.90$). A significant effect imposed by both Practitioners and TPs individually and together was found at the $p<0.05$ level; however, together they account for only 57.0% of the variance, with 43.0% of the variance unexplained by this model. From a a statistical perspective, Bland-Altman Plots of mean kMMT accuracy by Practitioner do show adequate repeatability since all scores fell within 2 SDs of the mean; however, the wide range of scores also suggests insufficient repeatability from a clinical perspective. Finally,ANOVA

demonstrated that an insignificant amount of variance could be explained by Block [$F(1,21) = 0.02$, $p = 0.90$].

Summary: The variation in the mean kMMT accuracy can only be explained 57% by participant characteristics; therefore, there are other factors at play that could not be explained by the model used. Additional research is needed to explain this variance.

Keywords: variability; stability; precision; reproducibility; repeatability; reliability; validity; intra-examiner; inter-examiner; kinesiology; muscle weakness; lie detection; deception; lying.

5.2 Introduction

According to Bossuyt, the first question to ask in the evaluation a new diagnostic test is "Does it measure what it is supposed to measure?" – otherwise known as its analytic validity.[73] Moreover, the first step in assessing a test's analytic validity is to estimate its accuracy, which can be measured as sensitivity and specificity, overall fraction correct, positive predictive value and negative predictive value and others. The previous studies in this series were aimed at exactly that: the estimation of the accuracy of kMMT to distinguish Lies from Truth. However, a diagnostic test is only considered valid if it is both accurate and precise; therefore, due to the wide range of kMMT accuracies found in previous studies, assessing the precision of kMMT is an important next step.

Precision can be defined as "the degree to which repeated measurements under unchanged conditions show the same results."[171] Just as there are numerous ways to quantify the accuracy of a diagnostic test,[73] there are several terms currently used to describe its precision, such as reproducibility, repeatability, reliability (inter-tester and intra-tester), and stability. In addition, some medical statisticians look at a test's confidence intervals when determining its precision.[78] However, it is most common to gauge the precision of a test in terms of its *reproducibility* and *repeatability*.[48] Unfortunately, these two terms are also frequently confused. For clarity, they are defined as:

> *Reproducibility* : the variability of the average values obtained by several observers while measuring the same item (interobserver variability).[48]
>
> *Repeatability* : the variability of the measurements obtained by one person while measuring the same item repeatedly (intraobserver variability).[48]

Applying these terms to the context of kMMT, *reproducibility*, then, may be described as the degree of variability in kMMT accuracy between different Practitioners testing the same TPs, and *repeatability* may be described as the degree of variability in kMMT accuracy when a Practitioner tests the same TP at different times.

Hence, the aim of this study was to assess the precision of kMMT used for distinguishing Lies from Truth, so that that both reproducibility ***and*** repeatability could be evaluated. More specifically, my research questions for this study became: (1) Is the kMMT accuracy that a Practitioner's achieves with one TP consistent over many TPs, or is it TP- or pair-specific?; and (2) Is the kMMT accuracy obtained with one TP consistent over many Practitioners, or is it Practitioner- or pair-specific?

5.3 Methods

This study is a prospective study of diagnostic test accuracy in a round-robin format. No participant was assessed prior to enrolment. This protocol received ethics committee approval by the Oxford Tropical Research Ethics Committee (OxTREC; Approval #41-10) and the Parker University Institutional Review Board for Human Subjects (Approval # R16_10). Also, this study protocol was registered with two clinical trials registries: the Australian New Zealand Clinical Trials Registry (ANZCTR; www.anzctr.org.au), and US-based ClinicalTrials.gov. Written informed consent was obtained from all participants, and all other tenets of the Declaration of Helsinki were upheld. This paper was written in accordance with the Standards for the Reporting of Diagnostic Test Accuracy Studies (STARD) guidelines (see Appendix D, page 376, for the STARD Checklist).[47, 66, 99]

5.3.1 Participants and Setting

Volunteer Practitioners were solicited from a group of muscle testing practitioners attending a seminar in Dallas, Texas, in June 2012. Regarding the Practitioners, all recruitment for participation, all enrolment and all data collection were done during the course of one afternoon and evening. In addition, seven (7) TPs were recruited and enrolled in the few days leading up to the event from a convenience sample of a mixture of kMMT-naïve and non-kMMT-naïve individuals. Similar to previous studies in this series (see Chapter 2, page 52; Chapter 3, page 116; and Chapter 4, page 150), participants were sought who were aged 18-65 years, had fully functioning and painfree upper extremities, and were fluent in English. Volunteers were excluded if they were markedly hearing-, sight- or speech-impaired. Recruitment was by direct contact and word of mouth.

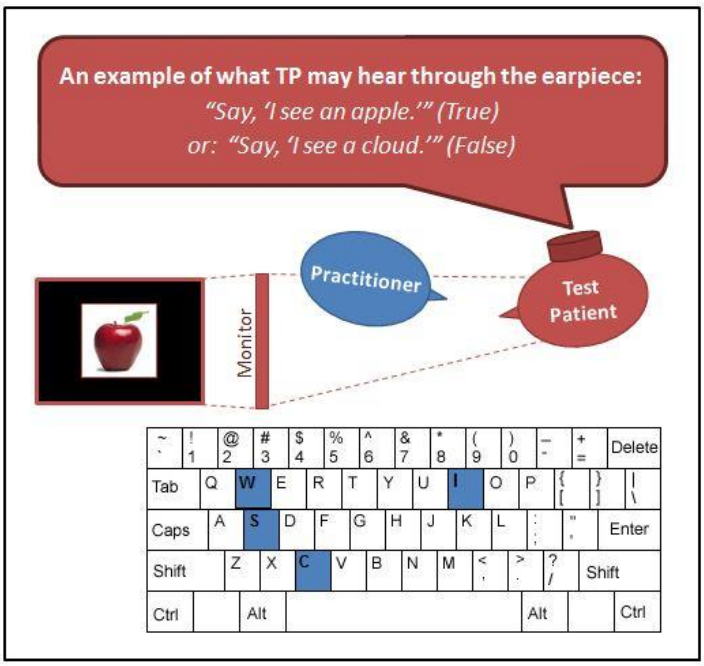
Once enrolled, Practitioners waited in a "holding room" where they were given a Participant Information Sheet (PIS) and completed a written informed consent form. They also completed similar Pre- and Post-Testing Questionnaires as were used in Studies 1 and 2 (see Appendix A, page 245). Once enrolled, the TPs waited in the testing room (i.e. a different room to the Practitioners), where they, too, were given a Participant Information Sheet (PIS) and completed a written informed consent form and Pre-Testing Questionnaires similar to what were used in Studies 1 and 2 (see Appendix A, page 245).

Aside from demographic information (e.g. gender, age, etc), the Pre-Testing Questionnaires asked participants (both Practitioners and TPs) to rate various characteristics on a 10cm Visual Analog Scale. For example, both Practitioners and TPs were asked to mark on the VAS their level of confidence in kMMT in general, with the left of the VAS anchored with "No Confidence Whatsoever (0%)" and on the right with "Complete Confidence (100%)."

They were also asked to rate their current level of test anxiety on a similar scale, with the left marked as “No Anxiety Whatsoever” and on the right with “Worst Anxiety Ever.” In addition, before and after each round, participants were asked to rate other factors (e.g. how well do they know this person, how much do they like this person, how much connection do they feel with this person, etc.) on an ordinal scale of 0 to 10 (with 0 the lowest and 10 the highest). To see the actual instruments employed, see Appendix A.5.

In the testing room, 7 complete testing stations were set up on 7 individual tables, evenly spaced around the room. Each testing station had a computer loaded with the research software, a keyboard, a mouse, an earpiece, and 2 chairs. The stations were configured in such a way that the TP could only see his/her monitor and no other monitors, and so that the Practitioner could not see the TP’s monitor. See Figure 5.1.

FIGURE 5.1 – Testing scenario layout: The Test Patient (red) viewed a monitor which the Practitioner could see, had an ear piece in his ear through which he received instructions. After the muscle test, the Practitioner (blue) entered his results on a keyboard.



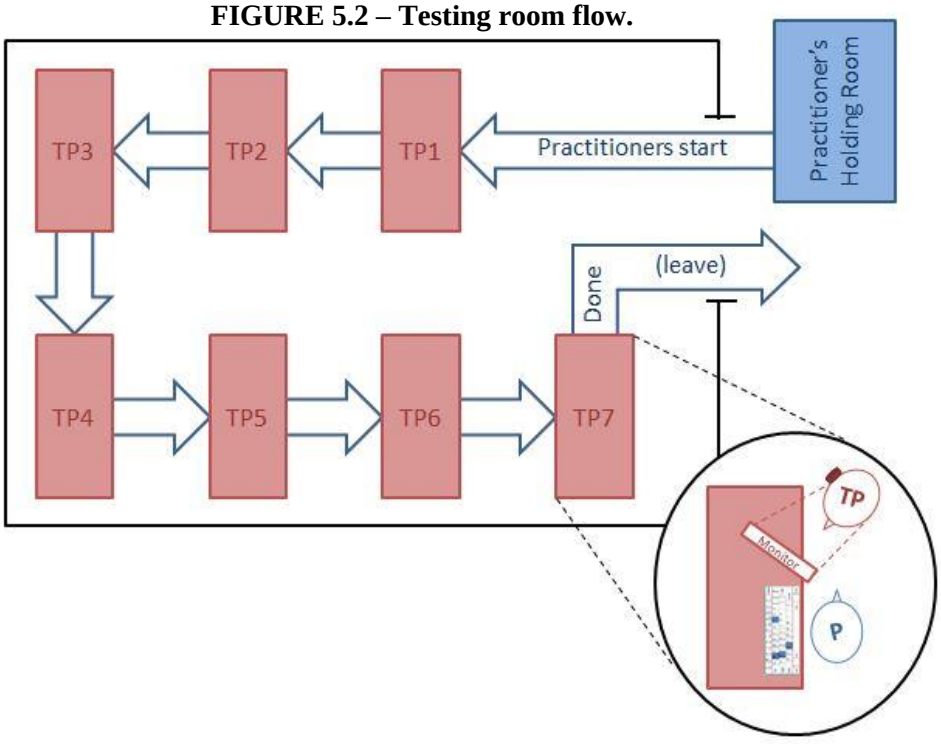
5.3.2 Test Methods

Fundamentally, the methodology of this study followed the same basic structure as Study 2 (see page 115): The target condition was deceit, the reference standard was the actual verity of the spoken statement, the primary index test used to detect deceit was kMMT, the secondary index testing was Intuition (without using kMMT). Each Practitioner-TP pair performed 20 kMMTs and 20 Intuits, broken up into 2 blocks of each: 10 kMMTs – 10 Intuits – 10 kMMTs – 10 Intuits. Each Practitioner tested all TPs and all TPs were tested by all Practitioners. All Practitioners were blind to the verity of the TP statement.

The stimuli presented were selected from the same database of 100 affect-neutral pictures/statements used in Studies 1 and 2. DirectRT™ Research Software (Empirisoft Corporation, New York, NY) was programmed to randomly present a unique sequence of visual and auditory stimuli for each TP, while randomizing the verity of the statements (i.e. True or False), and keeping the prevalence of False statements constant at 0.50.

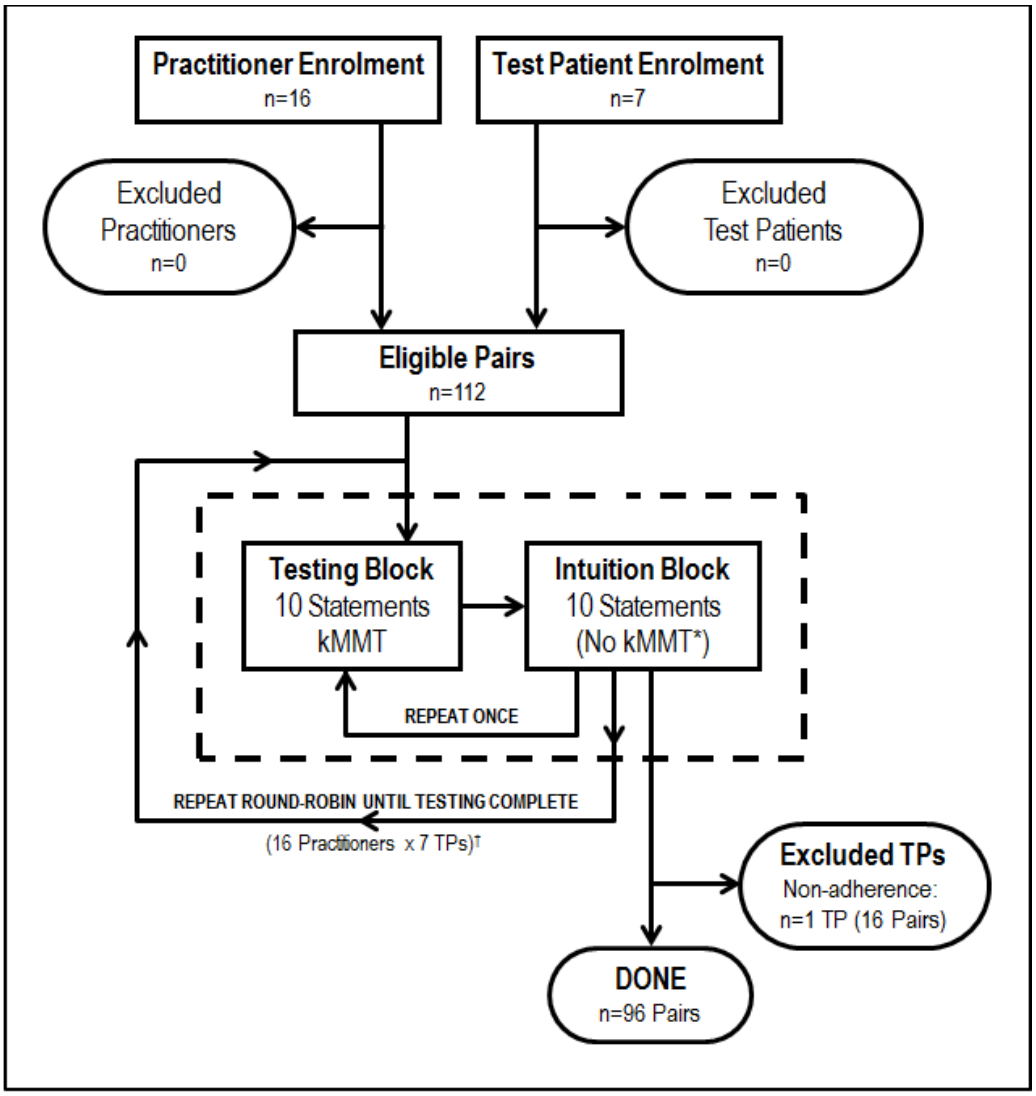
When testing began, the 7 TPs were seated at their respective tables (see Figure 5.2).

FIGURE 5.2 – Testing room flow.



Practitioners entered the testing room and sat with a TP. Before starting, they each completed a number of Pre-Test Ratings about each other, and the Practitioner could perform up to 5 practice kMMTs. Then the testing began. As soon as they finished each round, they completed a number of Post-Test Ratings about that round of testing, and then the Practitioner moved on to another testing station and another TP. Once a Practitioner completed testing all 7 TPs, s/he completed a Post-Test Questionnaire (see Appendix A, page 245) and then was done with his/her participation. After each TP was tested by all 16 Practitioners, they completed a short Post-Test Questionnaire (again, see Appendix A, page 245) and were also done with their participation. See Figure 5.3 for a Participant Flow Diagram.

FIGURE 5.3 – Participant Flow Diagram : Study 4.



kMMT, kinesiology-style Manual Muscle Testing; *Touching wrist & observing; †See also Figure 5.2.

5.3.3 Statistical Methods

5.3.3.1 Sample Size

Due to the nature of recruitment and the round-robin participation, a convenient sample of volunteers from the seminar was enrolled as Practitioners. No additional sample size calculation was performed. With 7 TPs confirmed as participating, it was hoped that at minimum 7 Practitioners would also volunteer. With more than double that projected number, I was confident that a meaningful analysis would result from the data collected.

5.3.3.2 Methods of Analysis

Because this is also a study of diagnostic test accuracy, for each Pair, I report error-based measures of accuracy: overall fraction correct, sensitivity, specificity, PPV and NPV [73] – and their 95% confidence intervals (95% CI). In addition, I report the mean measures grouped by both the Practitioner and the TP. The same error-based measures will also be reported for Intuition.

In regard to assessing reproducibility and repeatability, primarily graphical methods were used for analysis, and since mean kMMT accuracies can be calculated grouping by either Practitioners or TPs, scatterplots for each grouping are presented. Using scatterplots of kMMT Accuracy vs. Practitioner and kMMT Accuracy vs. TP, reproducibility was assessed visually by looking at the width of the range of mean kMMT accuracies, with smaller ranges indicating better reproducibility. Repeatability was assessed visually by using scatterplots of kMMT accuracies of Block 1 vs. kMMT accuracies of Block 2, and better repeatability was suggested by plots close to a reference line with a slope of 1 (m=1). Repeatability was also visually assessed using Bland-Altman plots of mean kMMT Accuracy vs. the Difference in kMMT Accuracy (Block 2 – Block 1), the “bias,” and included in these plots were reference

lines at the mean difference, and the mean difference ± 2SD (the limits of 95% agreement). It is expected that 95% of differences between the two measurements will fall within 2SDs of the mean.[172] With Bland-Altman plots, good correlation (i.e. *agreement*, and therefore, good repeatability) is a question of clinical judgment, not statistical. Nevertheless, the smaller the range between these two limits (±2SDs) the better the agreement, and the less the bias.

Further statistical analysis was carried out using an Analysis of Variance (ANOVA) to determine how much of the variance in scores could be attributed to different models. One model looked at the influence of Practitioners and TPs, and in another model, all participant characteristics were included (i.e. age, gender, years of experience, confidence, willingness, etc.).

Statistical advice was sought during the design phase and before data analysis. All data were analyzed using Stata/IC 12.1 (StataCorp LP, College Station, Texas), specifically the commands "*twoway scatter*" and "*anova*."

The study of variance / agreement in clinical testing may seem simple in principle, but in practice is extremely complex.[173] In actuality, the data collected in this study is also extremely complex – because it is not only nested (i.e. multiple tests by multiple Practitioners testing multiple TPs), the primary outcome (i.e. mean kMMT accuracy) can be calculated and averaged with respect to either the Practitioner or the TP. As a result, in-depth analyses of this data would require complicated and elaborate statistical methods, the like of which would be expected from a student writing a DPhil in statistics, but would be beyond the scope of a student writing a DPhil in clinical research. Therefore, the statistical analyses presented in this section reflect methods aligned with the level of knowledge expected by a clinical researcher, not a statistician.

5.4 Results

5.4.1 Participants

Sixteen Practitioners and 7 TPs were enrolled in late June 2012. Of the Practitioners, 8 were male and 8 were female; 14 were chiropractors, 2 were acupuncturists; 9 were in full-time practice, 6 were in part-time practice and 1 was not currently practising; their mean (SD) age was 45.1 (12.4) years; and 15 reported being right-handed and 1, left-handed. Their mean (SD) number of years in practice was 13.8 (10.0) years, their mean (SD) number of years of using kMMT in practice was 12.5 (8.8) years, and their mean usual hours/day using kMMT was 5.5 (3.4) hours. Seven Practitioners ranked their own kMMT expertise as "4," seven ranked their own kMMT expertise as "3," and two ranked their own kMMT expertise as "1." No Practitioners ranked their own kMMT expertise as either "2" or "0." The mean (SD) score of self-ranked kMMT expertise was 3.2 (0.7) out of a possible 4 (0="None" and 4="Expert"). As measured using the 10cm Visual Analog Scales (VAS), their mean (SD) degree of confidence in own kMMT ability (pre-testing) was 8.4 (1.5), their mean (SD) degree of confidence in kMMT in general (pre-testing) was 8.0 (1.6) and their median degree of test anxiety (range) was 0.7 (0.0 to 5.0). For a summary of Practitioner demographics, see Table 5.1. Also, for the Participant Flow Diagram, see Figure 5.3.

One of the 7 TPs (originally called TP#5) failed to follow written and verbal instructions which resulted in no data being collected by her computer; therefore, she was excluded from all analyses. For convenience, the TP originally called TP#7 was renamed TP#5. Of the 6 remaining TPs, 3 were male and 3 were female; their mean (SD) age was 36.7 (15.0) years; and all 6 reported being right-handed. As measured using 10cm VAS, their mean (SD; range) degree of experience with kMMT ability was 5.3 (3.6; 0.2 to 9.9), their mean (SD) degree of confidence in kMMT in general (pre-testing) was 8.0 (1.8) and their median degree of test

anxiety (range) was 0.1 (0.0 to 3.5). Finally, 3 TPs reported guessing the paradigm, and 3 TPs did not report guessing the paradigm.[i]

[i] Paradigm: Lies resulted in a "weak" kMMT, Truth resulted in a "strong" kMMT.

TABLE 5.1 – Demographics of Practitioners

	Practitioners (n=16)
Gender (M:F)	8:8
Mean age (SD)	45.1 (12.4)
Mean number of years in practice (SD)	13.8 (10.0)
Practitioner-type (*n*)	
Chiropractor	14
Acupuncturist	2
Practitioner Practice Status (*n*)	
Full-time	9
Part-time	6
Not practising	1
Mean years of kMMT experience (SD)	12.5 (8.8)
Mean hours of kMMT/day (SD)	5.5 (3.4)
Mean self-ranked kMMT Expertise* (SD)	3.2 (0.7)
Self-ranked as "4" (*n*)	7
Self-ranked as "3" (*n*)	7
Self-ranked as "1" (*n*)	2
Median degree of test anxiety**† (Min, Max)	0.7 (0.0, 5.0)
Mean degree of confidence in own kMMT ability (pre-testing)† (SD)	8.4 (1.5)
Mean degree of confidence in kMMT in general (pre-testing)†(SD)	8.0 (1.6)
Type(s) of kMMT Technique(s) used (*n*)††	
Neuro Emotional Technique (NET)	14
Applied Kinesiology (AK)	12
Total Body Modification (TBM)	2
Contact Reflex Analysis (CRA)	2
NeuroModulationTechnique (NMT)	2
Other‡	6

kMMT, kinesiology-style Manual Muscle Testing; SD, Standard Deviation; Min, Minimum; Max, Maximum; M, Male; F, Female.

* Self-ranked kMMT Expertise, ranged from 0=None to 4=Expert

** Test Anxiety refers to the amount of anxiety the Practitioner was expereincing just prior to testing

†Measured using a 10cm Visual Analog Scale, from 0="None" to 10="Most Ever"

†† Practitoners could respond with more than one technique.

‡ Other kMMT techniques included 1 Practitioner each: Chiropractic Plus Kinesiology (CPK), Directional Non-Force Technique (DNFT), Jaffe-Mellor Technique (JMT), Lifeline, Nambudripad's Allergy Elimination Techniques (NAET), NeuroLink, Touch for Health

5.4.2 Test Results

Participants took between 10 and 20 minutes to complete one round of testing. The duration of participation for Practitioners was 1 to 1 ¼ hours, and the duration of participation for the TPs was approximately 3 hours, which including rounds of testing interspersed with short rest periods of 5-10 minutes. There were no adverse events reported from any testing.

5.4.2.1 Accuracy

Accuracy scores were calculated for each Pair (n=96; see Appendix Table B.5.1), and mean accuracy scores were also calculated for each Practitioner and each TP (n=16 and n=6 respectively; see Table 5.2). For kMMT, the mean overall fraction correct (95% CI) was 0.616 (0.578 - 0.654), the mean sensitivity (95% CI) was 0.595 (0.549 - 0.640), the mean specificity (95% CI) was 0.638 (0.430 - 0.486), the mean Positive Predictive Value (PPV; 95% CI) was 0.632 (0.588 - 0.676), and the mean Negative Predictive Value (NPV; 95% CI) was 0.609 (0.5673 - 0.652). For Intuition, the mean overall fraction correct (95% CI) was 0.507 (0.484 - 0.530), the mean sensitivity (95% CI) was 0.456 (0.424 - 0.487), the mean specificity (95% CI) was 0.557 (0.527 - 0.588), the mean PPV (95% CI) was 0.502 (0.475 - 0.530), and the mean NPV (95% CI) was 0.514 (0.491 - 0.537). In all these 5 measures of accuracy, kMMT accuracy was found to be significantly more than both Intuition accuracy and Chance.[ii] See Table 5.3. Finally, there was no significant difference (p=0.91) in mean kMMT accuracies between those Pairs containing a TP who reported guessing the paradigm (mean 0.609, 95% CI 0.191 to 1.000) and those Pairs containing a TP who did not report guessing the paradigm (mean 0.623, 95% CI 0.397 to 0.849).

[ii] Chance here refers to the hypothetical situation where either outcome was equally likely: 50-50.

TABLE 5.2- Mean Accuracy Data for each Practitioner and each TP individually: Acuracy (Overall Percent Correct), Sensitivity, Specificity, PPV and NPV; for kMMT and Intution.

	Accuracy*				Sensitivity			Specificity			PPV			NPV		
	Mean	**95% CI**	**SD**	**Range**	**Mean**	**95% CI**	**SD**	**Mean**	**95% CI**	**SD**	**Mean**	**95% CI**	**SD**	**Mean**	**95% CI**	**SD**
kMMT																
Practitioner 1	0.550	0.340 - 0.760	0.200	0.300 - 0.750	0.550	0.306 - 0.794	0.232	0.550	0.324 - 0.776	0.215	0.539	0.291 - 0.787	0.236	0.571	0.369 - 0.773	0.193
2	0.500	0.390 - 0.610	0.105	0.350 - 0.600	0.583	0.480 - 0.687	0.098	0.417	0.236 - 0.597	0.172	0.508	0.410 - 0.606	0.094	0.490	0.350 - 0.630	0.133
3	0.633	0.479 - 0.788	0.147	0.450 - 0.850	0.567	0.371 - 0.762	0.186	0.700	0.426 - 0.974	0.261	0.675	0.500 - 0.850	0.167	0.603	0.451 - 0.756	0.145
4	0.617	0.433 - 0.800	0.175	0.400 - 0.800	0.744	0.640 - 0.849	0.100	0.505	0.168 - 0.841	0.320	0.618	0.425 - 0.812	0.184	0.619	0.379 - 0.859	0.228
5	0.600	0.395 - 0.805	0.195	0.350 - 0.900	0.683	0.503 - 0.864	0.172	0.517	0.232 - 0.802	0.271	0.609	0.407 - 0.810	0.192	0.603	0.356 - 0.851	0.236
6	0.717	0.562 - 0.871	0.147	0.600 - 0.950	0.644	0.399 - 0.889	0.233	0.789	0.644 - 0.935	0.139	0.743	0.586 - 0.900	0.150	0.713	0.554 - 0.872	0.152
7	0.658	0.464 - 0.853	0.186	0.350 - 0.850	0.583	0.391 - 0.776	0.183	0.733	0.497 - 0.970	0.225	0.698	0.495 - 0.901	0.193	0.632	0.443 - 0.821	0.180
8	0.792	0.568 - 1.000	0.213	0.400 - 1.000	0.900	0.785 - 1.000	0.110	0.683	0.300 - 1.000	0.366	0.781	0.573 - 0.989	0.198	0.766	0.358 - 1.000	0.388
9	0.550	0.409 - 0.691	0.134	0.450 - 0.800	0.513	0.275 - 0.750	0.226	0.592	0.367 - 0.818	0.215	0.546	0.370 - 0.722	0.168	0.560	0.417 - 0.703	0.136
10	0.525	0.353 - 0.697	0.164	0.250 - 0.700	0.424	0.345 - 0.503	0.075	0.621	0.358 - 0.884	0.250	0.556	0.347 - 0.765	0.199	0.508	0.342 - 0.675	0.159
11	0.592	0.376 - 0.808	0.206	0.300 - 0.800	0.704	0.527 - 0.880	0.168	0.483	0.119 - 0.848	0.347	0.604	0.395 - 0.814	0.200	0.578	0.270 - 0.886	0.294
12	0.733	0.559 - 0.908	0.166	0.500 - 0.950	0.644	0.461 - 0.828	0.175	0.818	0.636 - 1.000	0.173	0.780	0.564 - 0.996	0.206	0.705	0.552 - 0.858	0.146
13	0.708	0.497 - 0.919	0.201	0.400 - 0.900	0.579	0.229 - 0.930	0.334	0.828	0.692 - 0.963	0.129	0.708	0.396 - 1.000	0.297	0.718	0.505 - 0.932	0.204
14	0.658	0.403 - 0.914	0.244	0.350 - 1.000	0.646	0.394 - 0.898	0.240	0.673	0.358 - 0.987	0.300	0.675	0.392 - 0.958	0.270	0.649	0.382 - 0.916	0.254
15	0.517	0.302 - 0.731	0.204	0.150 - 0.750	0.417	0.124 - 0.709	0.279	0.617	0.295 - 0.938	0.306	0.582	0.247 - 0.916	0.318	0.515	0.327 - 0.704	0.180
16	0.508	0.351 - 0.665	0.150	0.350 - 0.700	0.329	0.173 - 0.485	0.149	0.678	0.510 - 0.846	0.160	0.491	0.250 - 0.732	0.230	0.518	0.392 - 0.645	0.121
TP 1	0.728	0.613 - 0.843	0.216	0.350 - 1.000	0.681	0.539 - 0.823	0.266	0.775	0.642 - 0.908	0.249	0.772	0.653 - 0.892	0.224	0.718	0.594 - 0.842	0.233
2	0.572	0.480 - 0.664	0.173	0.250 - 0.900	0.648	0.539 - 0.758	0.205	0.498	0.371 - 0.626	0.239	0.555	0.466 - 0.643	0.166	0.596	0.482 - 0.709	0.213
3	0.672	0.595 - 0.749	0.145	0.350 - 0.850	0.527	0.421 - 0.633	0.199	0.814	0.736 - 0.892	0.146	0.731	0.629 - 0.833	0.191	0.645	0.579 - 0.712	0.125
4	0.569	0.501 - 0.637	0.128	0.350 - 0.800	0.494	0.383 - 0.605	0.208	0.644	0.576 - 0.711	0.126	0.560	0.471 - 0.650	0.168	0.571	0.510 - 0.632	0.114
5	0.419	0.355 - 0.482	0.120	0.150 - 0.600	0.475	0.373 - 0.577	0.191	0.359	0.229 - 0.490	0.245	0.415	0.349 - 0.481	0.124	0.376	0.284 - 0.467	0.172
6	0.738	0.672 - 0.803	0.123	0.550 - 0.950	0.742	0.660 - 0.824	0.154	0.736	0.626 - 0.847	0.208	0.760	0.674 - 0.845	0.161	0.751	0.676 - 0.826	0.141
Intution																
Practitioner 1	0.542	0.411 - 0.672	0.124	0.400 - 0.750	0.600	0.412 - 0.788	0.179	0.483	0.344 - 0.623	0.133	0.531	0.405 - 0.656	0.120	0.553	0.410 - 0.696	0.136
2	0.500	0.395 - 0.605	0.100	0.350 - 0.600	0.420	0.258 - 0.582	0.154	0.573	0.354 - 0.791	0.208	0.501	0.342 - 0.660	0.151	0.498	0.408 - 0.589	0.086
3	0.392	0.261 - 0.522	0.124	0.250 - 0.600	0.283	0.204 - 0.362	0.075	0.500	0.312 - 0.688	0.179	0.379	0.211 - 0.548	0.160	0.403	0.293 - 0.514	0.105
4	0.542	0.458 - 0.626	0.080	0.400 - 0.600	0.500	0.434 - 0.566	0.063	0.583	0.461 - 0.706	0.117	0.551	0.459 - 0.643	0.088	0.535	0.456 - 0.615	0.075
5	0.550	0.462 - 0.638	0.084	0.450 - 0.650	0.459	0.324 - 0.595	0.129	0.641	0.544 - 0.738	0.093	0.549	0.428 - 0.671	0.116	0.554	0.478 - 0.629	0.072
6	0.525	0.433 - 0.617	0.088	0.400 - 0.650	0.574	0.459 - 0.689	0.110	0.477	0.332 - 0.622	0.138	0.519	0.413 - 0.625	0.101	0.534	0.453 - 0.616	0.078
7	0.533	0.470 - 0.597	0.061	0.450 - 0.600	0.450	0.362 - 0.538	0.084	0.617	0.462 - 0.771	0.147	0.554	0.456 - 0.652	0.093	0.525	0.475 - 0.576	0.048
8	0.542	0.435 - 0.649	0.102	0.400 - 0.700	0.456	0.289 - 0.622	0.159	0.623	0.544 - 0.702	0.075	0.529	0.404 - 0.654	0.119	0.549	0.449 - 0.649	0.095
9	0.517	0.352 - 0.681	0.157	0.250 - 0.700	0.483	0.332 - 0.635	0.144	0.547	0.300 - 0.794	0.236	0.522	0.324 - 0.721	0.189	0.519	0.345 - 0.693	0.166
10	0.475	0.420 - 0.530	0.052	0.400 - 0.550	0.424	0.381 - 0.467	0.041	0.527	0.429 - 0.626	0.094	0.468	0.399 - 0.537	0.066	0.483	0.442 - 0.524	0.039
11	0.508	0.396 - 0.620	0.107	0.400 - 0.700	0.437	0.225 - 0.649	0.202	0.574	0.530 - 0.619	0.042	0.480	0.345 - 0.615	0.129	0.529	0.410 - 0.648	0.114
12	0.492	0.370 - 0.613	0.116	0.350 - 0.650	0.450	0.305 - 0.595	0.138	0.533	0.362 - 0.705	0.163	0.491	0.345 - 0.638	0.140	0.487	0.376 - 0.599	0.106
13	0.533	0.350 - 0.717	0.175	0.300 - 0.800	0.424	0.220 - 0.628	0.194	0.642	0.449 - 0.836	0.185	0.529	0.267 - 0.790	0.249	0.536	0.394 - 0.678	0.136
14	0.500	0.293 - 0.707	0.197	0.150 - 0.650	0.574	0.309 - 0.840	0.253	0.426	0.222 - 0.630	0.194	0.486	0.297 - 0.676	0.181	0.534	0.277 - 0.792	0.246
15	0.442	0.311 - 0.572	0.124	0.250 - 0.600	0.383	0.229 - 0.538	0.147	0.500	0.385 - 0.615	0.110	0.429	0.285 - 0.573	0.137	0.451	0.331 - 0.571	0.114
16	0.525	0.470 - 0.580	0.052	0.450 - 0.600	0.374	0.243 - 0.505	0.125	0.673	0.592 - 0.753	0.077	0.518	0.449 - 0.588	0.066	0.529	0.477 - 0.581	0.050
TP 1	0.503	0.451 - 0.555	0.097	0.350 - 0.700	0.453	0.392 - 0.514	0.115	0.553	0.480 - 0.627	0.138	0.506	0.438 - 0.574	0.128	0.504	0.459 - 0.550	0.085
2	0.469	0.394 - 0.543	0.140	0.150 - 0.700	0.432	0.336 - 0.528	0.180	0.501	0.407 - 0.595	0.177	0.453	0.377 - 0.530	0.144	0.478	0.400 - 0.556	0.146
3	0.494	0.435 - 0.552	0.109	0.300 - 0.650	0.428	0.349 - 0.507	0.148	0.560	0.472 - 0.648	0.165	0.495	0.424 - 0.566	0.133	0.497	0.442 - 0.552	0.103
4	0.547	0.488 - 0.606	0.110	0.400 - 0.800	0.492	0.416 - 0.567	0.141	0.600	0.522 - 0.678	0.147	0.547	0.470 - 0.624	0.145	0.547	0.497 - 0.596	0.093
5	0.475	0.417 - 0.533	0.110	0.250 - 0.600	0.419	0.333 - 0.504	0.160	0.531	0.454 - 0.608	0.145	0.468	0.393 - 0.544	0.142	0.479	0.424 - 0.534	0.103
6	0.556	0.502 - 0.610	0.101	0.400 - 0.750	0.512	0.414 - 0.610	0.184	0.599	0.531 - 0.666	0.127	0.545	0.484 - 0.606	0.114	0.578	0.515 - 0.641	0.118

kMMT, kinesiology-style manual muscle testing; *Accuracy as Overall Fraction Correct; PPV, Positive Predictive Value; NPV, Negative Predictive Value; SD, Standard Deviation, SE, Standard Error, CI, Confidence Interval; TP, Test Patient.

TABLE 5.3 – Diagnostic accuracy of kMMT vs. Intuition: Means, 95% and significance. Accuracy (as overall fraction correct), sensitivity, specificity, positive predictive value, and negative predictive value.

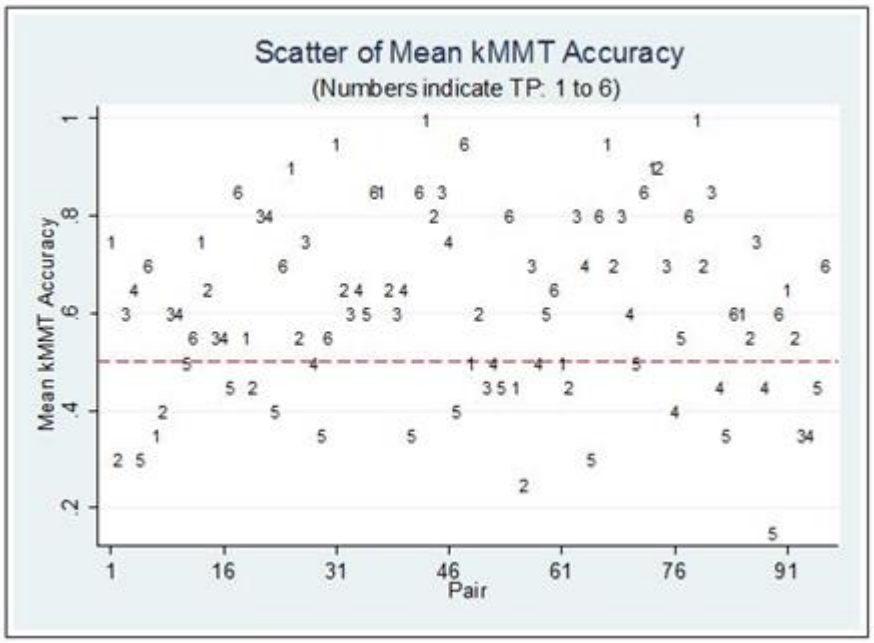
	kMMT			Intuition				*p*-value compared to Chance‡	
	n	**Mean**	**95% CI**	***n***	**Mean**	**95% CI**	***p*-value**	**kMMT**	**Intuition**
Accuracy*	96	0.616	0.578 - 0.654	96	0.507	0.484 - 0.530	**<0.01†**	**<0.01†**	0.53
Sensitivity	96	0.595	0.549 - 0.640	96	0.456	0.424 - 0.487	**<0.01†**	**<0.01†**	**0.01†**
Specificity	96	0.638	0.430 - 0.486	96	0.557	0.527 - 0.588	**0.01†**	**<0.01†**	**<0.01†**
Positive Predictive Value	96	0.632	0.588 - 0.676	96	0.502	0.475 - 0.530	**<0.01†**	**<0.01†**	0.87
Negative Predictive Value	96	0.609	0.5673 - 0.652	96	0.514	0.491 - 0.537	**<0.01†**	**<0.01†**	0.23

*Accuracy as Overall Fraction Correct; kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interva; ‡ 50-50 Chance; †Significance reached.

5.4.2.2 Reproducibility

In the context of this study, reproducibility was considered to be the amount of variance of the mean kMMT accuracy, and can be considered in terms of the Practitioner or in terms of the TP (see Figure 5.4).

FIGURE 5.4 – Scatterplot of kMMT accuracy by Pair.



Visual inspection of scatterplots of mean kMMT accuracies by Practitioner and by TP (Figure 5.5.A and 5.5.B, respectively) suggest large variances among both subsets. In addition, the scatterplot by Practitioner (Figure 5.5.A) suggests that when the Pair contained TP#1 or TP#6, kMMT accuracies were regularly among the highest of the sample, and with TP#5, among the lowest. I realise that there may be difficulties in interpreting the correlation coefficients between repeated measures;[48, 174] nonetheless, regression analysis revealed that kMMT accuracy could not be predicted by TP (r= –0.14; p=0.19), nor by Practitioner (r=0.01; p=0.90).

FIGURE 5.5.A – Reproducibility of kMMT accuracy by Practitioner: in order of mean accuracy.

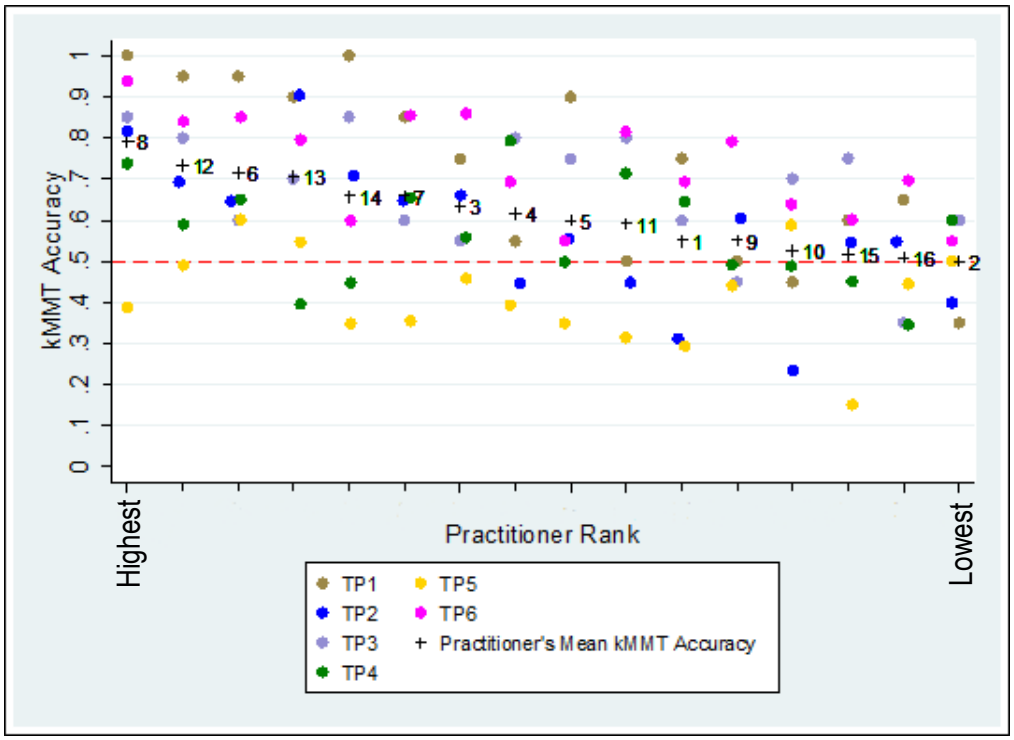
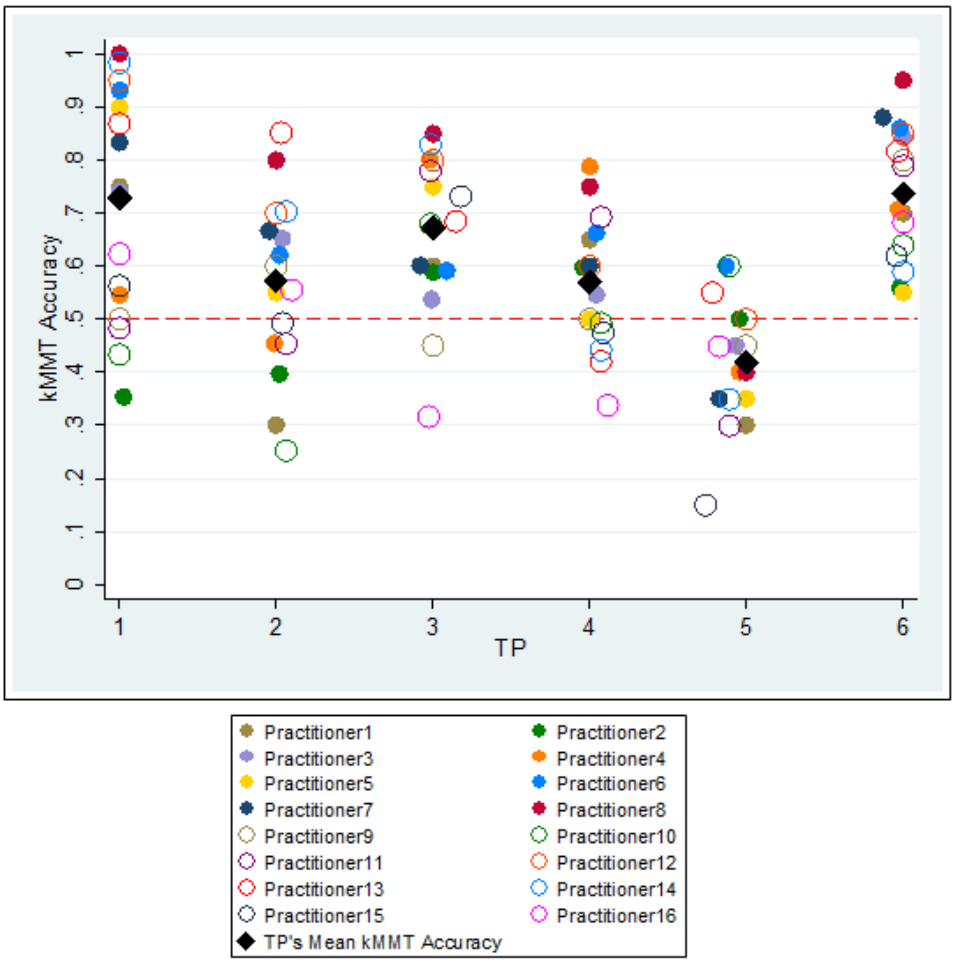


FIGURE 5.5.B – Reproducibility of kMMT accuracy by TP.



In addition, analyses of variance (ANOVA) were performed. There was a significant effect imposed by Practitioners and TPs individually and together on kMMT accuracy at the $p<0.05$ level (see Table 5.4 for details). However, together they account for only 57.0% of the variance (Practitioners, 21.6%; TPs, 35.4%), with 43.0% of the variance unexplained by this model. Another ANOVA was run to assess if Block had an influence on kMMT accuracy, and no significant influence was detected [$F(1,1) = 0.02$, $p = 0.90$] (see Appendix Table B.5.2).

TABLE 5.4 – ANOVA results : Practitioner and TP.

Source	Partial SS	df	F	Prob>F	%
Model	1.8963	20	4.97	<0.01	57%
Practitioner	0.7196	15	2.51	<0.01	21.6%
TP	1.1767	5	12.33	<0.01	35.4%
Residual	1.4312	75			43.0%
Total	3.3275	95			100.0%

ANOVA was also used to attempt to explain the residual factors. Using all variables collected, a significant effect for the model was demonstrated at the $p<0.05$ level [$F(1,88) = 4.15$, $p = 0.03$] (see Table 5.5.A). In this analysis, the model could account for 98.1% of the variance, leaving less than 2% unexplained. However, after obtaining statistical advice about analysing these ANOVAs, it was determined that there were too many variables in the model for the 98.1% result to be meaningful; therefore I include Table 5.5.A for completeness, but caution is advised about over-interpreting these results. Following on from these discussions, further ANOVAs were run using a univariate general linear model of the same variables, to investigate which participant characteristics may have had an influence on kMMT accuracy (see Table 5.5.B). No Practitioner characteristics' influence reached significance, unlike 3 TPs characteristics: (1) TP age, (2) TP anxiety, and (3) Confidence in Practitioner's kMMT Ability, with only TP age having a significant correlation, although negative ($r = –0.0047$;

$p<0.01$). Pursuant to these results, correlations were run to detect if any other participant factor could be associated to kMMT accuracy. Two Practitioner characteristics were found to significantly negatively correlate to kMMT accuracy: (1) Age ($r = –0.2986$; $p<0.01$), and (2) Year in practice ($r = –0.2461$; $p=0.02$). Also, 3 TP characteristics were found to significantly positively correlate to kMMT accuracy: (1) Age ($r = 0.2429$; $p=0.02$), and (2) Confidence in Practitioner ($r = 0.2347$; $p=0.02$), and (3) Confidence in Practitioner's kMMT ability ($r = 0.2362$; $p=0.02$). See Table 5.6. However, similar to the ANOVA results, caution is advised when interpreting these results because due to the many variables being analysed, they might not be meaningful.

TABLE 5.5.A – ANOVA for all variables.

Source	Partial SS	df	F	Prob>F	%
Model	**3.2648**	**88**	**4.15**	**0.03***	**98.1%**
Practitioner characteristics					
Connection with TP	0.4050	7	2.38	0.05	12.2%
Age	0.3503	10	3.92	**0.04***	10.5%
Gender	0.0031	1	0.35	0.58	8.9%
How well Practitioner knew TP	0.2245	4	2.31	0.08	6.7%
How well Practitioner liked TP	0.2211	5	1.82	0.14	6.6%
Confidence in own ability to test TP	0.1325	6	0.91	0.50	4.0%
TP's "willingness" to be tested	0.0646	3	0.89	0.46	1.9%
Years of kMMT Experience	0.0489	1	5.46	0.05	1.5%
Self-rated Anxiety	0.0349	5	0.29	0.92	1.1%
Profession	0.0177	1	1.98	0.20	0.5%
Number of Years in Practice	0.0070	2	0.39	0.69	0.2%
Currently Practising	0.0009	1	0.10	0.76	0.0%
TP characteristics					
How well TP liked Practitioner	0.2529	8	1.30	0.29	7.6%
Self-rated Anxiety	0.2401	7	1.41	0.24	7.2%
Confidence in Practitioner	0.2045	8	1.05	0.42	6.1%
Confidence in Practitioner's kMMT	0.1852	7	1.09	0.40	5.6%
Ability	0.1728	7	1.02	0.44	5.2%
Age	0.1295	4	3.62	0.07	3.9%
How well TP knew Practitioner	0.0495	2	1.02	0.37	1.5%
Gender	0.0268	1	2.99	0.13	0.8%
Residual	0.0626	7			1.9%
Total	3.3275	95			100.0%

SS, Sum of squares; df, degrees of freedom; F, f-statistic; Prob, probability; TP, Test Patient; *Reached significance

TABLE 5.5.B – Univariate general linear model using all variables individually.

Source	Partial SS	df	F	Prob>F	%	*r*	*p*-value
Practitioner characteristics							
Years of kMMT Experience	0.6777	12	1.77	0.07	20.4%	-0.0036	0.11
Number of Years in Practice	0.6171	11	1.74	0.08	18.5%	-0.0047	**0.02**
Age	0.4508	10	1.33	0.23	13.5%	-0.0046	**<0.01**
Connection with TP	0.1681	7	0.67	0.70	5.1%		
Confidence in own ability to test TP	0.1619	7	0.64	0.72	4.9%		
Self-rated Anxiety	0.1584	6	0.74	0.62	4.8%		
How well Practitioner liked TP	0.0633	5	0.35	0.88	1.9%		
How well Practitioner knew TP	0.0533	4	0.37	0.83	1.6%		
Profession	0.0336	1	0.96	0.33	1.0%		
Currently Practising	0.0300	2	0.42	0.66	0.9%		
TP's "willingness" to be tested	0.0167	3	0.16	0.93	0.5%		
Gender	0.0094	1	0.27	0.61	0.3%		
TP characteristics							
Age	1.1767	5	9.85	**<0.01**	**35.4%**	-0.0047	**<0.01**
Self-rated Anxiety	0.7710	7	0.379	**<0.01**	**23.2%**	0.0101	0.29
Confidence in Practitioner's kMMT Ability	0.7103	8	2.95	**0.01**	**21.3%**	0.0139	0.50
Confidence in Practitioner	0.4798	8	1.83	0.08	14.4%	0.0206	0.38
Connection with Practitioner	0.3357	9	1.07	0.39	10.1%	-0.0123	0.42
How well TP liked Practitioner	0.2083	9	0.64	0.76	6.3%		
Gender	0.1544	1	4.57	0.04	4.6%		
How well TP knew Practitioner	0.0463	2	0.32	0.86	1.4%		

SS, Sum of Squares; df, degrees of freedom; F, f-statistic; Prob, probability; TP, Test Patient; * Reached significance.

TABLE 5.6 – Significant Results of Correlations Testing

Participant Characteristic	*r*	*p*-value
Practitioner characteristics		
Age	-0.2986	<0.01
Number of Years in Practice	-0.2461	0.02
TP characteristics		
Age	0.2429	0.02
Confidence in Practitioner	0.2347	0.02
Confidence in Practitioner's kMMT Ability	0.2362	0.02

r, correlation coefficient; TP, Test Patient

5.4.2.3 Repeatability

Repeatability was considered to be the amount of variance in the kMMT accuracy between Block 1 and Block 2 for each Pair. It can be reported by Practitioner or by TP. In tests with good repeatability, scatterplots of Block 1 scores vs. Block 2 scores will hover along a diagonal line (slope=1) indicating identical scores (see Figure 5.6).

FIGURE 5.6 – Blank repeatability scatterplot. The diagonal line represents identical scores between Block 1 and Block 2. The red lines represent the likelihood of Chance (0.500). Therefore, the better scores are to the right and towards the top, and pairs with good repeatability will hover around the diagonal line.

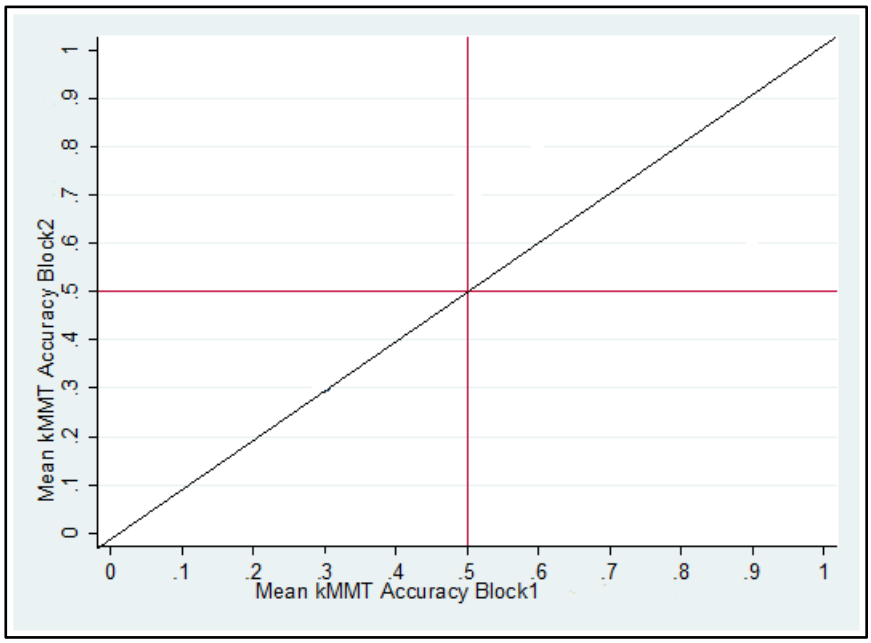
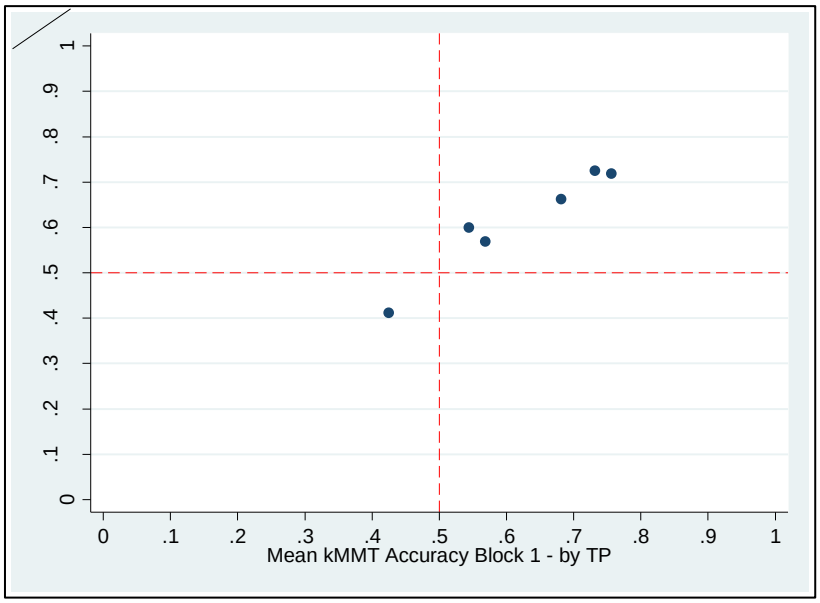


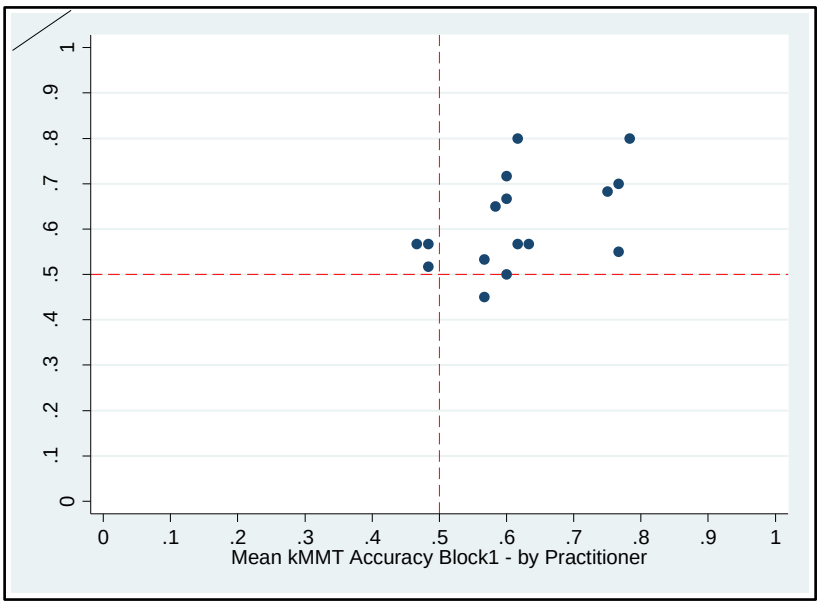
Figure 5.7 shows scatterplots of mean kMMT accuracies by Practitioner (A) and by TP (B). Visual inspection of these scatterplots suggests a reasonable amount of agreement between mean kMMT accuracies in Blocks 1 and 2, especially with respect to TPs (B), which suggests adequate repeatability.

In contrast, visual inspection of similar individual scatterplots of kMMT scores for each Practitioner (Appendix Figure B.5.1) suggest that some Practitioners showed good repeatability (e.g. #12 and #15), while others demonstrated poor repeatability (e.g. #7 and #9). Likewise visual inspection of similar scatterplots for each TP, showed noticeably superior repeatability for some TPs (e.g. TP #1) than others (e.g. TP #4). See Appendix Figure B.5.2.

FIGURE 5.7 – Repeatability scatterplots : Mean kMMT accuracy – Block 1 vs Block 2. (A) by TP, and (b) by Practitioner.



(A)

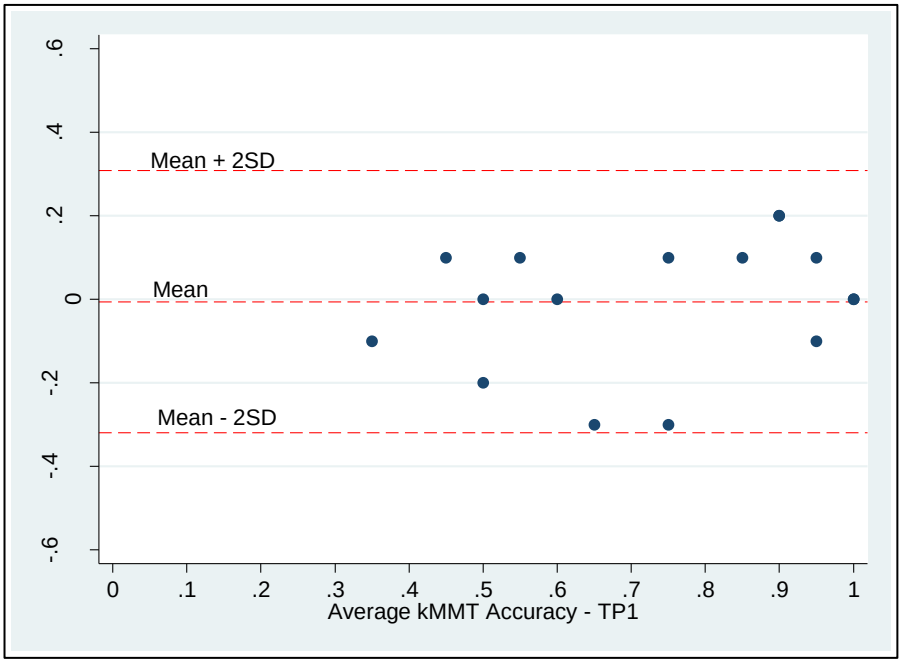


(B)

Bland-Altman Plots were created for each TP, which plotted their mean kMMT accuracies with each Practitioner vs. the difference in their mean accuracies (Block 2 – Block 1). See Figures 5.10. For 3 of the 6 TPs, all scores fell within 2 SDs of the mean, indicating sufficient

repeatability;[175] however, from a clinical perspective, the large SDs of the mean scores (see large band widths in Figures 5.10) suggest poor agreement by Block, and thus poor repeatability. In addition, ANOVA demonstrated that an insignificant amount of variance could be explained by Block alone [F(1,21) = 0.02, p = 0.90].

FIGURE 5.10 – Bland-Altman Plots by TP : Difference against mean for kMMT accuracies.



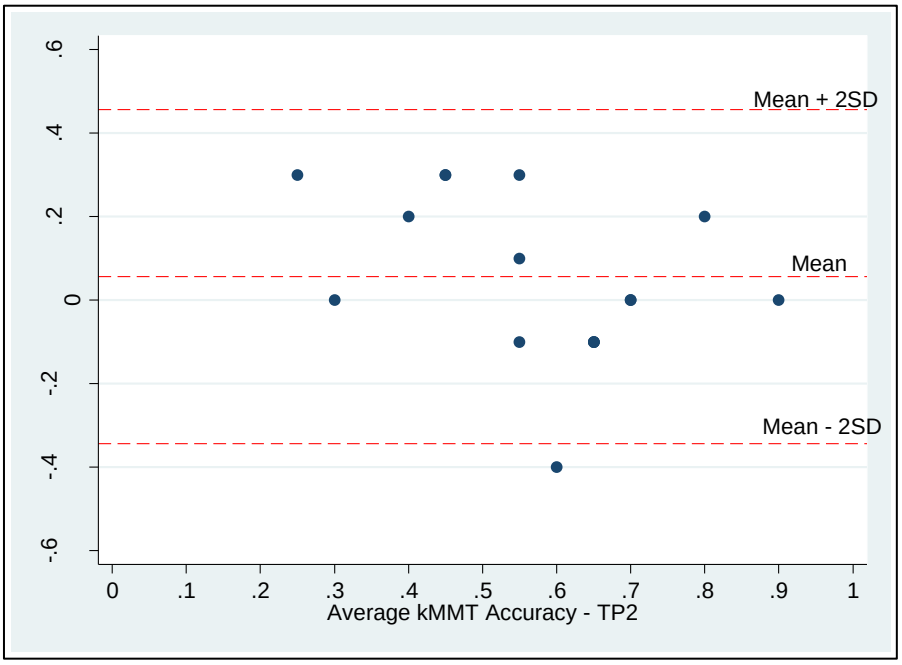
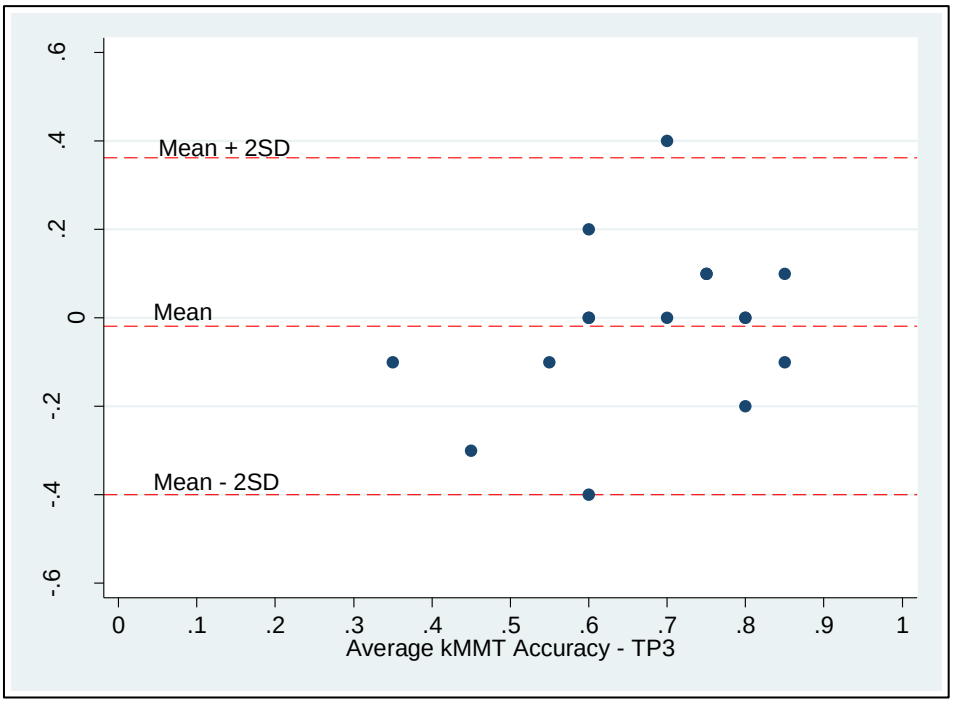


FIGURE 5.10 (con't.)



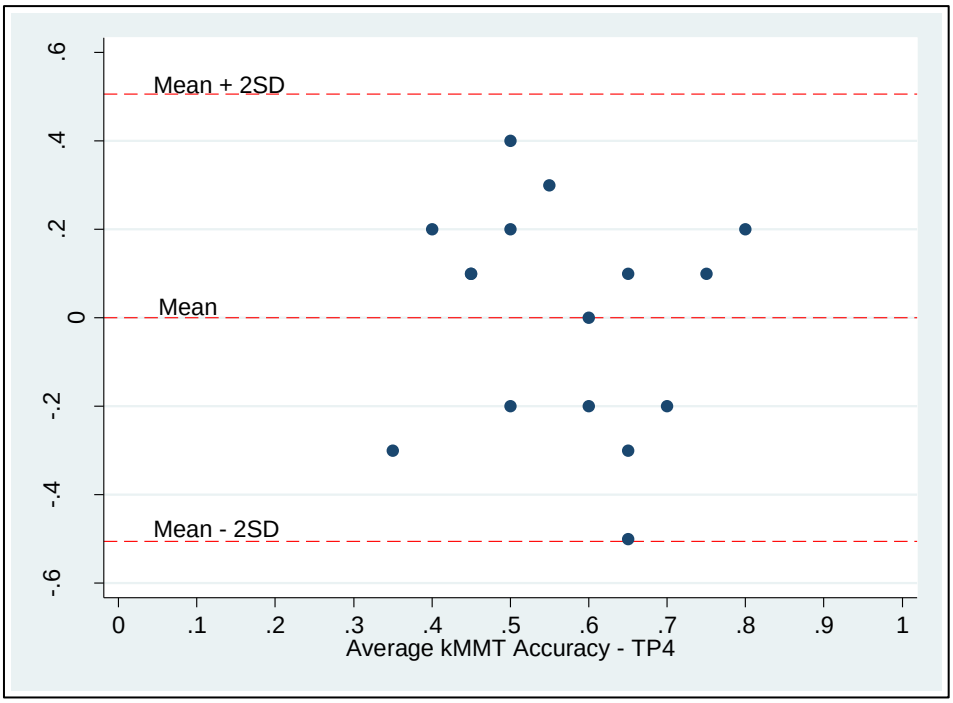
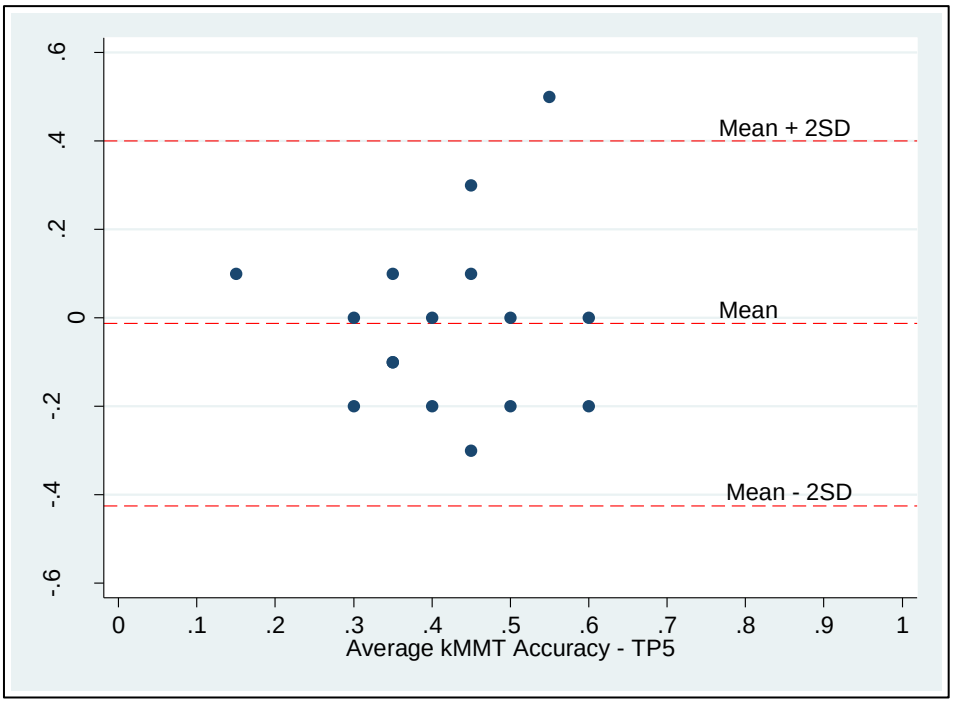
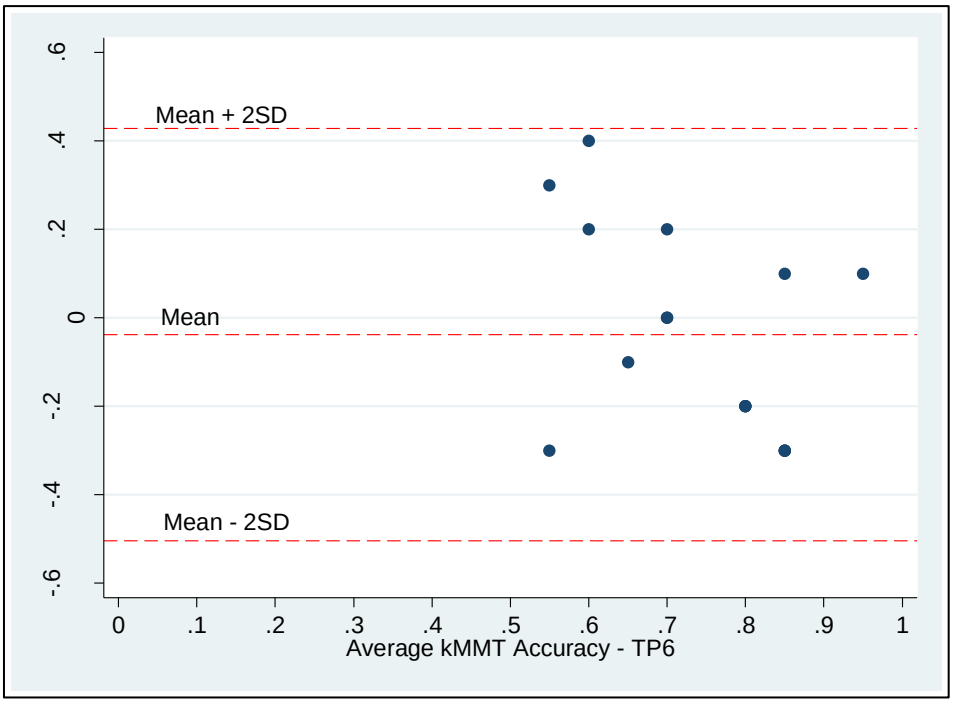


FIGURE 5.10 (con't.)





5.5 Discussion

5.5.1 Statement of Principal Findings

Supporting results from earlier studies, kMMT once again was found to distinguish Lies from Truth significantly more accurately than either Chance or Intuition. Also, the finding that the mean specificity, 0.638 (95% CI 0.430 to 0.486), was more than the mean sensitivity, 0.595 (95% CI 0.549 to 0.640), suggests that Truths were generally easier to detect than Lies; however, the difference between these means did not reach significance (p=0.1759), so caution is advised when interpreting these results.

Only 57% of the between-Pairs variance in mean kMMT accuracy could be explained by the Pair itself, leaving 43% attributable to unknown factors. The within-Pair variance of mean kMMT accuracy suggests adequate repeatability. In addition, visual inspection of reproducibility and repeatability scatterplots and ANOVA results seems to suggest that stability of kMMT accuracy may be more TP-specific than Practitioner-specific. The results for each Practitioner, individually, suggest that both reproducibility and repeatability may be sufficiently stable for some Practitioners, and insufficient for others. The results for each TP, individually, suggest the same. Overall, analyses of both reproducibility and repeatability of kMMT accuracy showed variances that could not be explained by any single factor.

5.5.2 Comparisons to Other Studies

There are a number of studies published in the muscle testing literature which have attempted to quantify the reliability of muscle testing used in various capacities. Using AK-MMT, Conable reports finding fair intra-tester agreement (κ=0.54),[164] Perot et al. report finding good reliability, and[176] Pollard et al. report finding good agreement between a novice practitioner and an experienced practitioner when using AK-MMT.[55] In 2 studies also using

AK-MMT mixed inter-examiner agreement was found.[6, 177] On the other hand, systematic reviews of AK-MMT found that its reliability could not be adequately determined,[14, 49, 151] and in 2 studies using kMMT both intra-tester and inter-tester reliability were found to be insufficient.[178, 179] The mixed results of these reports, along with the findings of this present study, speak to the difficulty of exploring the variability of MMT.

5.5.3 Strengths and Limitations

A strength of this study is that its results support the findings of earlier studies, therefore, demonstrating that kMMT accuracy can be adequately estimated using rigorous scientific methods and that these methods produce durable results. Another strength are the breadth of the types of the kMMT-practitioners enrolled, and the degrees of experience of all participants. In addition, similar to other studies in this series, testing during this study was as true to clinical practice as possible in a research setting. A limitation of this study is, again, its generalisability to other applications of kMMT, to kMMT using muscles other than the deltoid, and to other forms of MMT. Also, a weakness in the study design may have been the duration of participation of the TPs: 3+ hours in total. This amount of time may have adversely impacted their performance or their compliance to strict procedures.

5.5.4 Implications for Clinical Practice

Naturally, a clinician would like to know how stable or reliable kMMT accuracy is. S/He would be interested in knowing if it can be relied upon from one patient to the next (reproducibility) and with the same patient from one visit to the next (repeatability). Therefore, the primary concern is whether the largest variability is small enough to be clinically meaningful,[175] and the results of this study suggest that this must be taken on a pair-

by-pair basis. On the other hand, how reliable kMMT accuracy must be in order for it to be useful is a clinical decision, not a statistical one.[180]

5.5.5 Unanswered Questions and Future Research

The results of this study suggest that the accuracy of kMMT used in this way may be sufficiently reproducible and repeatable. However, since kMMT is a test used by practitioners to guide treatment usually within the context of a specific protocol or technique system, to assess the true usefulness of kMMT, randomised, controlled trials must be carried out to assess the effectiveness of the various technique systems that employ kMMT. In other words, aside from kMMT being accurate or precise in and of itself, it must be ascertained if its use leads to improved patient outcomes, such as a better quality of life. Future research must focus on responding to this concern.

5.6 Summary

The accuracy of kMMT used for distinguishing lies from truth and the reproducibility and repeatability of kMMT accuracy were assessed and found to be sufficient; however, there factors at play that could not be explained by the model used. Additional research is needed to explain the variance.

5.7 Chapter 5 – List of Tables and Figures

5.7.1 Tables

5.7.2 Figures

CHAPTER 6

Study 5 – Using Emotionally-Arousing Stimuli

"It shows the truth - that the real meaning of a word

is only as powerful or harmless as the emotion behind it."

Sarah Silverman

CHAPTER 6 : STUDY 5 – USING EMOTIONALLY-AROUSING STIMULI

6.1 ABSTRACT

Research Objectives: To determine if using emotionally-arousing stimuli influences kMMT accuracy compared to affect-neutral stimuli.

Methods: A prospective study of diagnostic test accuracy was carried out. Twenty Practitioners who routinely practised kMMT were paired with Test Patients (TPs) who may or may not have been kMMT-naïve. The Pairs performed 40 kMMTs as TPs spoke True and False statements about a mix of affect-neutral and emotionally-arousing pictures. Blocks of kMMT alternated with blocks of Intuition. The verity of the spoken statements was randomly assigned, with the prevalence of Lies fixed at 0.50.

Results: kMMT accuracy using emotionally-arousing stimuli was no better or worse than when using affect-neutral stimuli (p=0.35). However, using all stimuli, kMMT accuracy (0.648; 95% CI 0.558 - 0.737) was found to be significantly better than Intuition accuracy (0.526; 95% CI 0.488 - 0.564; p=0.01) and Chance (0.500; p<0.01). In addition, similar to previous studies in this series, this study also failed to detect any characteristic that consistently influenced kMMT accuracy.

Summary: This study found that using emotionally-arousing stimuli was no different from using affect-neutral stimuli. However, this study would have been strengthened by adding personally-relevant, high-stakes lies instead of lies instead of emotionally-arousing (impersonal) stimuli. The primary limitation of this study is its lack of generalisability to other applications of kMMT. The main strengths of this study were its choice of a "gold standard" as the reference standard and its high degree of blinding. Finally, this study is

further evidence that a simple yet robust methodology for assessing the value of kMMT as a diagnostic tool can be developed and implemented effectively.

Keywords: sensitivity; specificity; kinesiology; muscle weakness; lie detection; deception; lying; arm; upper extremity; emotional stress.

6.2 Introduction

Polygraphs operate on the idea that lying causes certain physiological changes, and the higher the stakes of the lie, the more accurate the polygraph reading.[181] A thread of a similar concept runs through many kMMT technique systems: It is a common theory among some practitioners that a stress in the body is related to a weakening of a muscle.[11, 24, 182] Therefore, if kMMT has been found to achieve a certain degree of accuracy at detecting Lies using affect-neutral stimuli (see previous chapters), then I hypothesise that the use of emotionally-arousing stimuli may serve to increase its accuracy.

Considering what factors may influence the accuracy of a diagnostic test is important for both clinicians and researchers. A fundamental element of clinical research is the use of some measure to detect if a change has occurred. Therefore, the results of a study hinge upon the validity of the selected measure: Choose the wrong measure, or one that lacks sufficient sensitivity (for the sample population), and the study will be both meaningless and an irresponsible waste of time and other resources. Therefore, knowing how to produce the best possible results in kMMT testing will be of value to kMMT researchers and kMMT practitioners alike. Furthermore, since a diagnostic test is only valuable to clinicians if it leads to a correct diagnosis and effective treatment, kMMT practitioners will benefit from knowing more about what type of stimuli will elicit a truer kMMT response.

Similar to the objects they represent, pictures and words can cause physiological and behavioural reactions.[183-185] The International Affective Picture System (IAPS) is a database of over 1000 pictures that were rated by a large group of people (men and women) for the feelings they evoked.[101] Likewise, the Affective Norms for English Words (ANEW) is a database of English words with associated emotional ratings, which complements the IAPS.[104] These sets of pictures and words have been rated for pleasure, arousal, and

dominance, and the average reported emotional impact are listed along with its standard deviation. Together these databases provide an emotional stimulus standardisation necessary for rigorous scientific analysis.

This study used pictures and words from these databases, with specific valences[i] known to be either neutral or emotionally arousing. The primary aim of this study was to determine if the use of emotionally-arousing stimuli had an impact on kMMT accuracy, compared to affect-neutral stimuli.

6.3 Methods

This study is a prospective study of diagnostic test accuracy. No participant was assessed prior to enrolment. This protocol received ethics committee approval by the Oxford Tropical Research Ethics Committee (OxTREC; Approval #41-10) and the Parker University Institutional Review Board for Human Subjects (Approval # R17_10). Also, this study protocol was registered with two clinical trials registries: the Australian New Zealand Clinical Trials Registry (ANZCTR; www.anzctr.org.au), and US-based ClinicalTrials.gov. Written informed consent was obtained from all participants, and all other tenets of the Declaration of Helsinki were upheld. This paper was written in accordance with the Standards for the Reporting of Diagnostic Test Accuracy Studies (STARD) guidelines (see Appendix D, page 378, for the STARD Checklist).[47, 66, 99]

Essentially, the methodology of this study followed closely to that of Study 2 (see page 115), with the exception that emotionally-arousing pictures were mixed with the affect-neutral pictures from the database used in previous studies. Otherwise, these components remained

[i] See glossary

the same: the target condition (Lying), index test (kMMT), reference standard (the actual verity of the spoken statement), the secondary index test (Intuition), study population, participant recruitment and sampling, enrolment criteria, sample size (n=20 Pairs), testing scenario, testing methods, participant flow and prevalence of Lies.

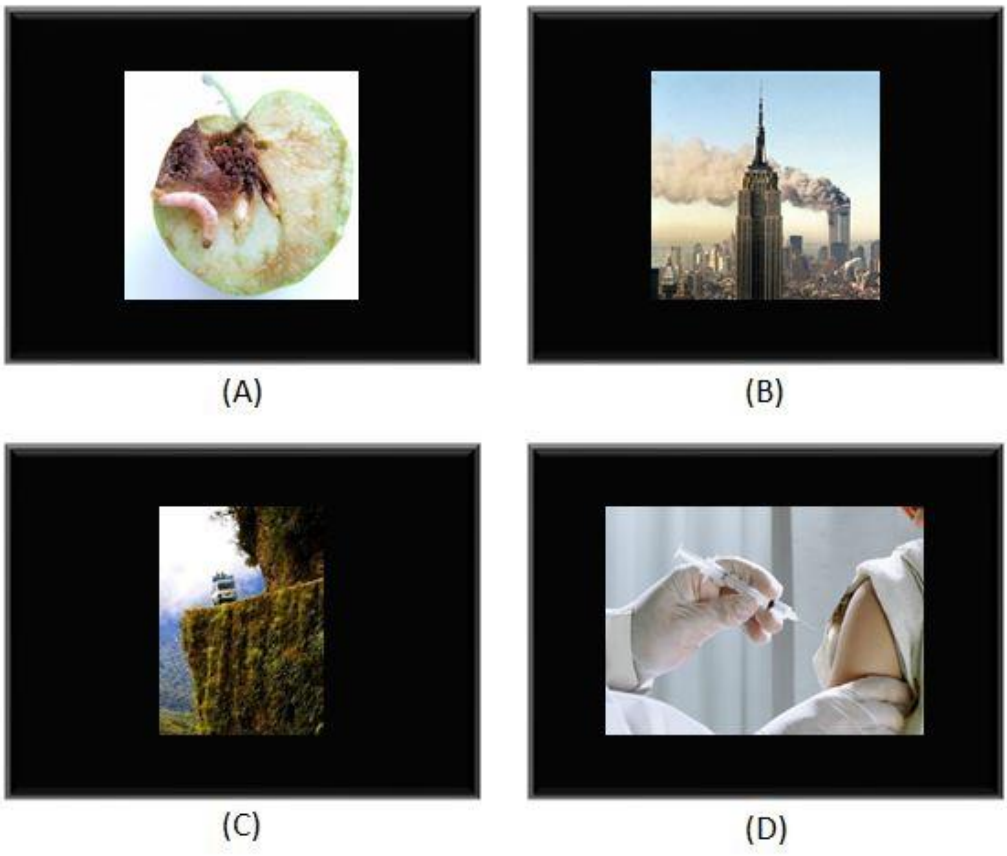
6.3.1 Participants and Setting

Two groups of participants were recruited: (A) Healthcare practitioners (n=20) who routinely use kMMT in practice ("Practitioners"), and (B) Test Patients (n=20; "TPs"). Practitioners and TPs were recruited in the same manner as in Study 2 (see page 116), in the American state of California; however, a mixture of kMMT-naïve and non-naïve TPs were included, as were a mix of TPs who knew their paired Practitioner and those who did not.

6.3.2 The Stimuli

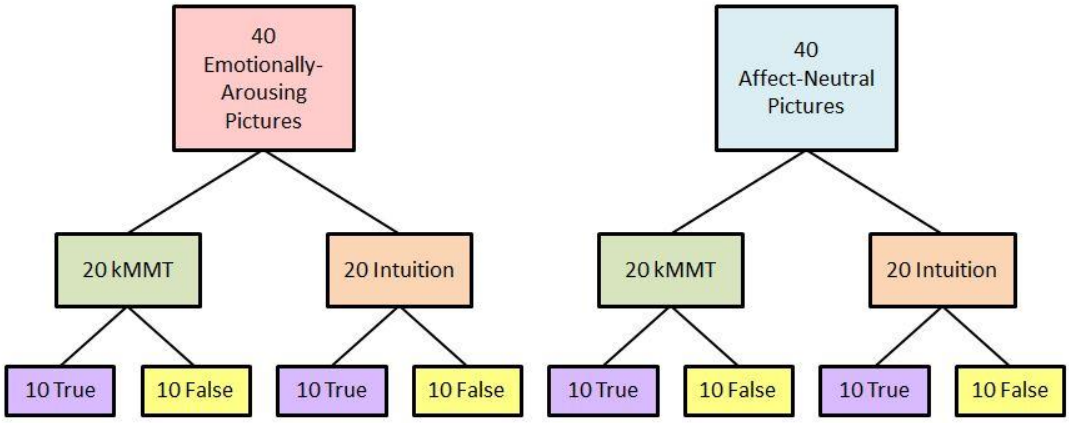
The visual stimuli presented were a mix of affect-neutral pictures from the database used in previous studies and pictures that were emotionally-arousing. The emotionally arousing pictures were chosen for their similarity to those in the International Affective Picture System (IAPS; National Institute of Mental Health Center for Emotion and Attention, University of Florida, Gainesville, FL)[100] which had mean arousal levels above 7.0,39 and supplemented with additional similar pictures. Whenever possible, the pictures were paired with statements containing words from the Affective Norms for English Words (ANEW; National Institute of Mental Health Center for Emotion and Attention, University of Florida, Gainesville, FL), which had a mean arousal valence above 4.8.[104] For examples of emotionally-arousing pictures, see Figure 6.1.

FIGURE 6.1 – Examples of affective visual stimuli used in this study. (A), (B), (C) and (D) are examples that could have been presented to a Test Patient during either the kMMT or the Intuition Blocks.



For this study, 40 emotionally-arousing and 40 affect-neutral pictures were placed into a database. Of the 80 (2 x 40) pictures, half of each group was allocated to the kMMT Blocks and half to the Intuition Blocks. In addition, half of these subgroups were paired with True statements and half with False statements, so that the prevalence of Lies was again fixed at 0.50. For clarity of this breakdown, refer to Figure 6.2, which describes how the emotional valence, verity and Blocks were distributed. The order of stimuli was randomly chosen and presented using DirectRT™ Research Software (Empirisoft Corporation, New York, NY), so that each Pair was presented with a unique sequence of stimuli.

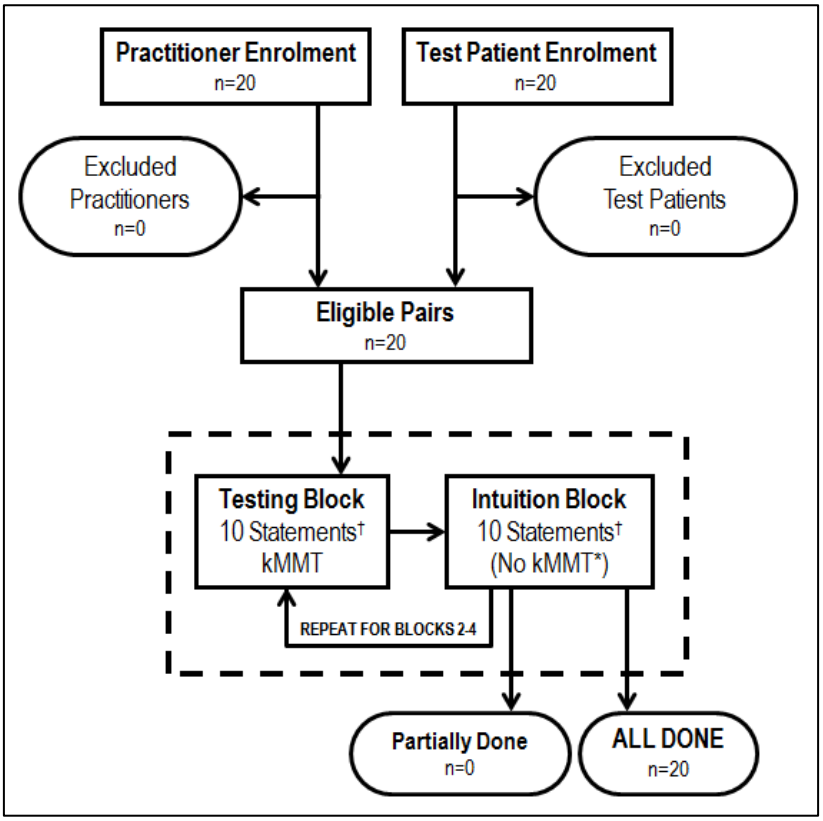
FIGURE 6.2 – Distribution of emotional valence of pictures.



6.3.3 The Testing Scenario

The testing scenario was the same as in Study 2 (see page 117). Each Practitioner performed 40 kMMTs on the TP, broken up into 4 blocks of 10 tests each and recorded their results in the same manner. Four (4) Intuition Blocks alternated with 4 kMMT Blocks. All Practitioners were blind to the verity of the TP statement.See Figure 6.3 for the Participant Flow Diagram. Also, participants completed the same pre- and post-testing questionnaires.[186]

FIGURE 6. 3 – Participant Flow Diagram : Study 5 – Emotional Stimuli.



6.3.4 Statistical Methods

No new sample size calculation was performed for this study, but kept at 20 Practitioner-TP pairs. As in Study 2 (see page 126), this study was not powered for subgroup analyses but will be shown for completeness. Again, I report error-based measures of accuracy for both kMMT and Intuition: overall fraction correct[73], sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) – and their 95% confidence intervals (95% CI). Statistical advice was sought, during the design phase and for data analysis for this study. All data were analyzed using STATA 17.0, specifically the commands ttest and *pwcorr, sig*.

6.4 Results

6.4.1 Participants

Twenty unique Practitioner-TP pairs were enrolled in October and November 2011. Included were 13 female and 7 male Practitioners, and 12 female and 8 male TPs. Of the 20 Practitioners, there were 14 chiropractors, 1 mental health professional, 1 acupuncturist, 1 naturopath, 1 other health professional and 2 other professionals (non-health).

Twelve Practitioners were in full-time practice, 8 were in part-time practice, and none enrolled were currently not practicing. The Practitioners' mean (SD) number of years in practice was 16.8 (12.7) years. The mean age for Practitioners was 48.5 (12.0) years, and for TPs, 37.9 (12.4) years. For a summary of Practitioner demographics, see Table 6.1. In addition, there were 13 TPs who were kMMT-naïve and 7 who had prior experience with kMMT, and 8 TPs knew their paired Practitioner and 12 who did not.

6.4.2 The Stimuli

As outlined in the Methods section, for emotionally-arousing stimuli, chosen for inclusion in the database of stimuli were pictures with Arousal Scores over 7.0 and words with arousal scores of over 4.8. The overall mean (SD) picture arousal score was 4.8 (1.3), for emotionally-arousing stimuli, the mean (SD) was 7.6 (0.5), and for affect-neutral stimuli, the mean (SD) was 4.9 (0.6). The overall mean (SD) word arousal score was 5.0 (1.1), for emotionally-arousing stimuli, the mean (SD) was 6.0 (0.7), and for affect-neutral stimuli, the mean (SD) was 4.8 (1.2). For both pictures and words, their arousal scores were normally distributed (see Appendix Figure B.6.2). For picture-word pairs if the sum of their arousal scores were in excess of 9.8 it was considered emotionally-arousing, otherwise it was considered affect-neutral.

6.4.3 Test Results

Pairs took between 10 and 45 minutes to complete their participation. All Pairs completed all testing in full. Aside from TP arm fatigue, there were no adverse events reported from any testing. All accuracies were normally distributed (see Appendix Figure B.6.1), so parametric statistics were used, mainly the Student t-test and ANOVA.

6.4.3.1 kMMT and Intuition Accuracies

I first will compare accuracies using emotionally-arousing and affect-neutral stimuli, and then I will report accuracies using all stimuli. Using only emotionally-arousing stimuli, the mean (95% CI) kMMT accuracy (i.e. overall fraction correct) for kMMT was 0.632 (0.544 - 0.720), which was significantly different from Chance[ii] (0.500; p=0.01) but *not* from the mean (95% CI) Intuition accuracy, 0.545 (0.491 - 0.599; p=0.09). To calculate sensitivity, specificity, PPV and

[ii] Chance here refers to the hypothetical situation where either outcome was equally likely: 50-50.

TABLE 6.1 – Demographics of Practitioners.

	Practitioners (n=20)
Gender (M:F)	11:9
Mean age (SD)	48.5 (12.0)
Mean number of years in practice (SD)	16.8 (12.7)
Practitioner-type (*n*)	
Chiropractor	14
Mental Health Professional	1
Acupuncturist	1
Naturopath	1
Other Health Professional	1
Other Professional	2
Practitioner Practice Status (*n*)	
Full-time	12
Part-time	8
Not practising	0
Mean years of kMMT experience (SD)	17.6 (12.2)
Mean hours of kMMT/day (SD)	8.6 (10.6)
Mean self-ranked kMMT Expertise* (SD)	3.5 (0.8)
Median test anxiety**† (Min, Max)	2.9 (0.0, 9.4)
Mean confidence in own kMMT ability (pre-testing)† (SD)	8.9 (1.8)
Mean confidence in kMMT in general (pre-testing)†(SD)	8.5 (2.0)
Type(s) of kMMT Technique(s) used (*n*)†† §	
Neuro Emotional Technique (NET)	15
Applied Kinesiology (AK)	10
Total Body Modification (TBM)	7
Nutrition Response Testing (NRT)	3
Koren Specific Technique (KST)	2
Nambudripad's Allergy Elimination Techniques (NAET)	2
NeuroLink	2
Other‡	14

kMMT, kinesiology-style Manual Muscle Testing; SD, Standard Deviation;
Min, Minimum; Max, Maximum; M, Male; F, Female; SD, Standard Deviation

* Self-ranked kMMT Expertise, ranged from 0=None to 4=Expert

** Test Anxiety, the degree of anxiety the Practitioner was expereincing just prior to testing

†Measured using a 10cm Visual Analog Scale, from 0="None" to 10="Most Ever"

§ One Practitioner did not respond to this question

†† Practitoners could respond with more than one technique.

‡ Other kMMT techniques included 1 Practitioner each: Bio Energetic Synchronization Technique (BEST), Biokinetics, BodyTalk, Clinical Kinesiology (CK), Contact Reflex Analysis (CRA), Directional Non-Force Technique (DNFT), Eden Energy Medicine (EEM), Lifeline, Muscle Response Testing (MRT), Neural Organization Technique (NOT), Neurological Integration System (NIS), NeuroModulationTechnique (NMT), Psych-K, Quantum Neurology.

NPV, I calculated these same statistics for each pair and report their means (95% CIs): sensitivity was 0.589 (0.453 - 0.725), specificity, 0.681 (0.575 - 0.788), PPV, 0.669 (0.577 - 0.760) and NPV, 0.641 (0.534 - 0.748). See Table 6.2. Finally, the mean kMMT accuracy using only emotionally-arousing stimuli was ***not*** significantly different from kMMT accuracy using only affect neutral stimuli (p=0.35). See Table 6.3. The same mean statistics are reported for the Intuition condition in Table 6.2. The 2x2 tables for each Pair can be found in Appendix Table B.6.2.

Using only affect-neutral stimuli, the mean (95% CI) kMMT accuracy (i.e. overall fraction correct) for kMMT was 0.659 (0.560 - 0.757), which was significantly different from both Chance (p=0.01), and the mean (95% CI) Intuition accuracy, 0.508 (0.459 - 0.556; p=0.01). The mean (95% CI) kMMT sensitivity was 0.645 (0.521 - 0.770), specificity, 0.671 (0.545 - 0.796), PPV, 0.654 (0.538 - 0.770) and NPV, 0.675 (0.581 - 0.769). See Tables 6.2 and 6.3. The same mean statistics are reported for the Intuition condition in Table 6.2.

TABLE 6.2 – Diagnostic accuracy : Overall fraction correct, sensitivity, specificity, positive predictive value, and negative predictive value (n=20 Pairs) for kMMT & Intuition. All stimuli compared to emotionally-arousing stimuli and affect-neutral stimuli.

			All Stimuli		Emotionally-Arousing Stimuli†		Affect-Neutral Stimuli‡	
		n	Mean	95% CI	Mean	95% CI	Mean	95% CI
kMMT	**Overall Fraction Correct**	20	0.648	0.558 - 0.737	0.632	0.544 - 0.720	0.659	0.560 - 0.757
	Sensitivity	20	0.620	0.500 - 0.740	0.589	0.453 - 0.725	0.645	0.521 - 0.770
	Specificity	20	0.675	0.570 - 0.780	0.681	0.575 - 0.788	0.671	0.545 - 0.796
	Positive Predictive Value	20	0.653	0.559 - 0.747	0.669	0.577 - 0.760	0.654	0.538 - 0.770
	Negative Predictive Value	20	0.651	0.559 - 0.744	0.641	0.534 - 0.748	0.675	0.581 - 0.769
Intuition	**Overall Fraction Correct**	20	0.526	0.488 - 0.564	0.545	0.491 - 0.599	0.508	0.459 - 0.556
	Sensitivity	20	0.483	0.417 - 549	0.480	0.393 - 0.567	0.486	0.414 - 0.558
	Specificity	20	0.574	0.505 - 0.643	0.610	0.534 - 0.686	0.533	0.436 - 0.631
	Positive Predictive Value	20	0.556	0.513 - 0.599	0.546	0.471 - 0.621	0.567	0.512 - 0.622
	Negative Predictive Value	20	0.501	0.464 - 0.539	0.543	0.497 - 0.590	0.452	0.397 - 0.506

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Combined Emotional Arousal Scores > 9.8; ‡ Combined Emotional Arousal Scores <= 9.8.

TABLE 6.3 – The influence of stimuli valence on accuracy.

				p-value
PICTURES	**Mean**	**95% CI**	***p*-value**	**Compared to Chance**
Affect-Neutral				
kMMT	0.661	0.561 - 0.762	**0.01***	**<0.01***
Intuition	0.526	0.480 - 0.752		0.25
Emotionally-Arousing				
kMMT	0.631	0.542 - 0.720	0.08	**0.01***
Intuition	0.527	0.468 - 0.586		0.36
kMMT				
Affect-Neutral	0.661	0.561 - 0.762	0.34	
Emotionally-Arousing	0.631	0.542 - 0.720		
Intuition				
Affect-Neutral	0.526	0.480 - 0.572	0.98	
Emotionally-Arousing	0.527	0.468 - 0.586		
WORDS				
Affect-Neutral				
kMMT	0.658	0.552 - 0.764	**<0.01***	**0.01***
Intuition	0.485	0.436 - 0.534		0.53
Emotionally-Arousing				
kMMT	0.638	0.555 - 0.721	0.15	**<0.01***
Intuition	0.568	0.513 - 0.622		**0.02***
kMMT				
Affect-Neutral	0.658	0.552 - 0.764	0.51	
Emotionally-Arousing	0.638	0.555 - 0.721		
Intuition				
Affect-Neutral	0.485	0.436 - 0.534	**0.02***	
Emotionally-Arousing	0.568	0.513 - 0.622		
COMBINED				
Affect-Neutral				
kMMT	0.659	0.560 - 0.757	**0.01***	**<0.01***
Intuition	0.508	0.459 - 0.556		0.75
Emotionally-Arousing				
kMMT	0.632	0.544 - 0.720	0.09	**0.01***
Intuition	0.545	0.491 - 0.599		0.10
kMMT				
Affect-Neutral	0.659	0.560 - 0.757	0.35	
Emotionally-Arousing	0.632	0.544 - 0.720		
Intuition				
Affect-Neutral	0.508	0.459 - 0.556	0.26	
Emotionally-Arousing	0.545	0.491 - 0.599		

kMMT, kinesiology-style Manual Muscle Testing; CI,Confidence Interval.

Using all stimuli, the mean (95% CI) accuracy (i.e. overall fraction correct) for kMMT was 0.648 (0.558 - 0.737), which was significantly different from the mean (95% CI) Intuition accuracy, 0.526 (0.488 - 0.564; p=0.01), and Chance (p<0.01).

The other accuracy statistics for kMMT and Intuition are reported in Table 6.2, and True vs. False comparisons can be found in Appendix Table B.6.1. The plot of kMMT Sensitivity vs. Specificity can be found at Figure 6.4. In addition, it is noticed that these statistics for Study 1 (see page 78) fell within this study's 95% CI, implying that the results of the 2 studies were similar. Correlations of kMMT by Block were also run for both Emotionally-arousing and Affect Neutral stimuli. No correlations reached significance for the Emotionally-arousing stimuli. While some Block's accuracies were correlated using Affect-neutral stimuli, the correlations did not display a consistent pattern (see Table 6.4).

Figure 6.4 – Scatterplot graph of sensitivity of kMMT vs. specificity of kMMT. Those that scored above the green line did better than Chance.

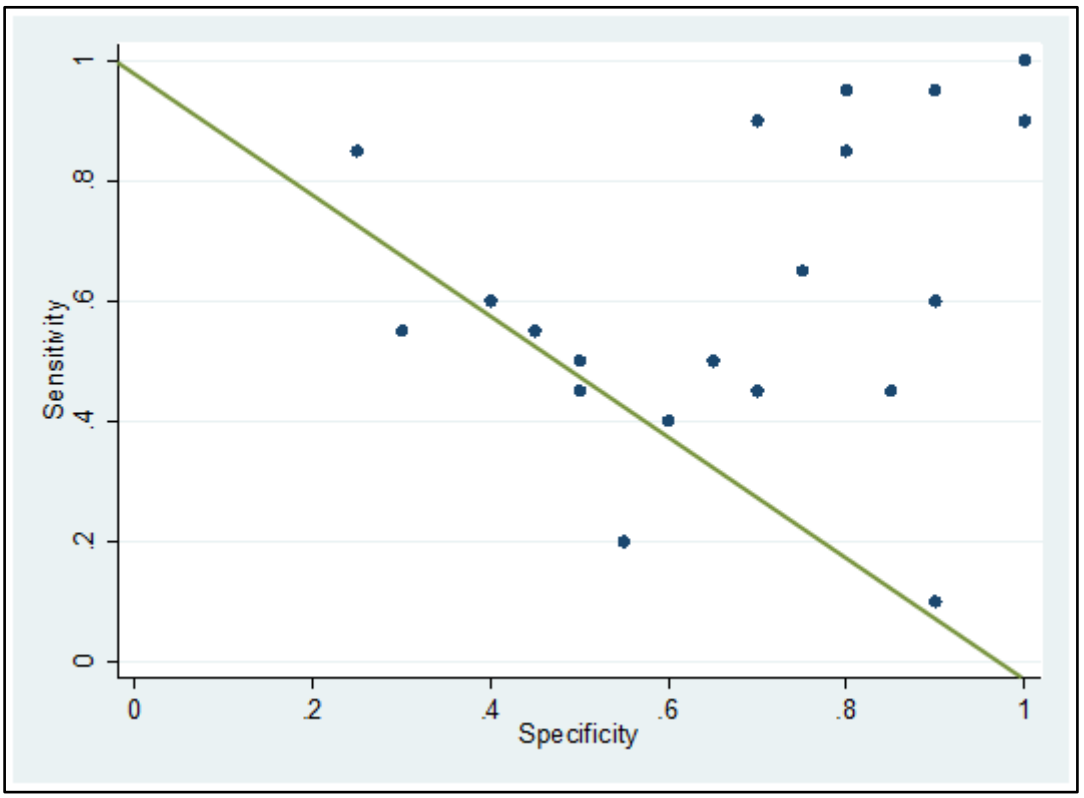


TABLE 6.4 - Correlations (r) with p-values among kMMT accuracies by Block. Using (A) emotionally-arousing stimuli, and (B) affect-neutral stimuli.

(A)	Block 1	Block 2	Block 3
Block 1	1.0000		
Block 2 *p-value*	0.0201 *0.93*	1.0000	
Block 3 *p-values*	0.1548 *0.51*	0.3077 *0.19*	1.0000
Block 4 *p-values*	0.2125 *0.38*	0.1605 *0.51*	-0.1189 *0.63*

kMMT, kinesiology-style Manual Muscle Testing.

(B)	Block 1	Block 2	Block 3
Block 1	1.0000		
Block 2 *p-value*	0.3776 *0.10*	1.0000	
Block 3 *p-values*	0.6343 ***<0.01****	0.5588 ***0.01****	1.0000
Block 4 *p-values*	0.8118 ***<0.01****	0.2591 *0.27*	0.5485 ***0.01****

kMMT, kinesiology-style Manual Muscle Testing; * Significance Reached.

6.4.3.2 Potential Influencing Factors

As mentioned above, this study was not powered to do subgroup analyses, but for completeness, I compared kMMT accuracies for the different arousal scores by various participant characteristics, and there results are outlined in Tables 6.5 to 6.9.

First, looking specifically at Practitioner characteristics that might have had an influence, I grouped the pairs by Practitioner profession, Practitioner practising status and Practitioner self-ranked kMMT expertise. Table 6.5 shows that none of these subgroupings were found to be significantly different from each other, except for self-ranked kMMT expertise using only affect-neutral stimuli: Twelve Practitioners rated themselves as a "4" (i.e. "Expert"), and 8 as a "3," "2," or "1." None ranked themselves as a "0." The mean (95% CI) kMMT accuracy for

4-ranked Practitioners using affect-neutral stimuli was 0.732 (0.592 - 0.872), and for the 8 other Practitioners, 0.549 (0.429 - 0.669), which was found to be significantly different (p=0.04).

TAB TABLE 6.5 - The influence on various Practitioner categorical factors on kMMT accuracy: (1) profession, (2) practising status, and (3) self-ranked kMMT expertise. Using (A) emotionally-arousing stimuli, and (B) affect-neutral stimuli.

		kMMT Accuracy					
		(1) Practitioner Profession		(2) Practitioner Practising Status		(3) Self-ranked kMMT Experise (0-4)*	
		Chiropractors (n=14)	All others (n=6)	Full Time (n=12)	Part Time (n=8)	4 (n=12)	3, 2 or 1 (n=8)
(A) Emotionally-Arousing Stimuli†	Mean	0.609	0.686	0.603	0.676	0.676	0.566
	95% CI	0.497 - 0.721	0.500 - 0.872	0.479 - 0.727	0.525 - 0.827	0.541 - 0.812	0.461 - 0.671
	p -value	0.41		0.40		0.16	
(B) Affect-Neutral Stimuli‡	Mean	0.615	0.761	0.601	0.745	0.732	0.549
	95% CI	0.495 - 0.735	0.559 - 0.962	0.469 - 0.734	0.583 - 0.906	0.592 - 0.872	0.429 - 0.669
	p -value	0.16		0.14		**0.04***	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Combined Emotional Arousal Scores > 9.8; ‡ Combined Emotional Arousal Scores <= 9..8;
* Practitioners were asked to rank their own kMMT ability from 0 ("None") to 4 ("Expert"). No Practitioners responded "0".

TABLE 6.6 - The influence on kMMT technique system on kMMT accuracy. Using (A) emotionally-arousing stimuli, and (B) affect-neutral stimuli.

		Practitioner's kMMT Technique System(s)†			
		NET (n=15)	AK (n=10)	TBM (n=7)	All Others‡ (n=12)
(A) Emotionally-Arousing Stimuli†	Mean	0.627	0.624	0.672	0.632
	95% CI	0.522 - 0.733	0.467 - 0.780	0.450 - 0.894	0.517 - 0.747
	p -value (ANOVA)	0.98			
(B) Affect-Neutral Stimuli‡	Mean	0.646	0.630	0.702	0.681
	95% CI	0.524 - 0.769	0.467 - 0.794	0.445 - 0.959	0.550 - 0.812
	p -value (ANOVA)	0.85			

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Practitioners may be included in more than one group;
‡ Other kMMT techniques included: Bio Energetic Synchronization Technique (BEST), Biokinetics, BodyTalk, Clinical Kinesiology (CK), Contact Reflex Analysis (CRA), Directional Non-Force, Biokinetics, BodyTalk, Clinical Kinesiology (CK), Contact Reflex Analysis (CRA), Directional Non-Force Technique (DNFT), Eden Energy Medicine (EEM), Lifeline, Muscle Response Testing (MRT), Nambudripad's Allergy Elimination Techniques (NAET), Neural Organization Technique (NOT), Neurological Integration System (NIS), NeuroModulationTechnique (NMT), Psych-K, and Quantum Neurology.

TABLE 6.7 - The influence of gender on kMMT accuracy. (1) Practitioner gender, (2) Test Patient gender, and (3) Practitioner-Test Patient sameness of gender. Using (A) emotionally-arousing stimuli, and (B) affect-neutral stimuli.

		kMMT Accuracy					
		(1) Practitioner Gender		(2) Test Patient Gender		(3) Practitioner & TP Gender	
		Males (n=11)	Females (n=9)	Males (n=8)	Females (n=12)	Same (n=11)	Different (n=9)
(A) Emotionally-Arousing Stimuli†	Mean	0.588	0.686	0.544	0.691	0.647	0.614
	95% CI	0.481 - 0.696	0.522 - 0.851	0.447 - 0.642	0.560 - 0.823	0.507 - 0.787	0.484 - 0.744
	p -value	0.27		0.06		0.70	
(B) Affect-Neutral Stimuli‡	Mean	0.585	0.749	0.598	0.699	0.684	0.628
	95% CI	0.450 - 0.720	0.600 - 0.898	0.471 - 0.725	0.548 - 0.851	0.554 - 0.814	0.446 - 0.810
	p -value	0.08		0.26		0.58	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Combined Emotional Arousal Scores > 9.8; ‡ Combined Emotional Arousal Scores <= 9.8.

TABLE 6.8 - The influence Test Patient arm used on kMMT accuracy. Using (A) emotionally-arousing stimuli, and (B) affect-neutral stimuli.

		Test Patient's Arm Used	
kMMT Accuracy		Dominant (n=3)	Non-Dominant (n=17)
(A) Emotionally-Arousing Stimuli†	Mean	0.706	0.619
	95% CI	0.036 - 1.000	0.528 - 0.711
	p -value	0.64	
(B) Affect-Neutral Stimuli‡	Mean	0.768	0.639
	95% CI	0.214 - 0.1.00	0.532 - 0.747
	p -value	0.43	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval;
† Combined Emotional Arousal Scores > 9.8;
‡ Combined Emotional Arousal Scores <= 9..8.

Stratifying by technique system practiced also did not find any significant differences between subgroups, using either emotionally-arousing stimuli (p=0.98) or affect-neutral stimuli (p=0.85). See Table 6.6. Also, there was no significant difference between any of the three Gender subgroupings or the choice of TP arm subgrouping, using either emotionally-arousing stimuli or affect-neutral stimuli (see Tables 6.7 and 6.8, respectively). Likewise, if the TP wore glasses did not seem to influence accuracy, using either emotionally-arousing stimuli or affect-neutral stimuli (see Table 6.9).

Finally, 9 TPs reported guessing the paradigm, whereas 11 TPs did not report guessing the paradigm. For all stimuli, for just emotionally-arousing stimuli and for just affect-neutral stimuli, these 2 groups did not differ significantly in kMMT accuracy (p=0.10, p=0.06, and p=0.21 respectively). In addition, comparing the mean kMMT accuracies of those Pairs whose TPs were kMMT-naïve (n=13) to those Pairs whose TPs were not kMMT-naïve (n=7) for all stimuli, for just emotionally-arousing stimuli and for just affect-neutral stimuli, also found no significant differences (p=0.26, p=0.50, and p=0.21). Lastly, comparing the mean kMMT accuracies of those Pairs who knew each other (n=8) to those Pairs did not know each other (n=12) for all stimuli, for just emotionally-arousing stimuli and for just affect-neutral stimuli, also found no significant differences (p= 0.48, p=0.22, and p=0.70).

TABLE 6.9 - The influence of various categorical TP characteristics on kMMT accuracy. (1) The Test Patient guessing the paradigm, (2) The Test Patient wearing glasses during testing, (3) Test Patient experience with kMMT, and (4) If Test Patient knew Practitioner. Using (A) emotionally-arousing stimuli, and (B) affect-neutral stimuli.

		Mean kMMT Accuracies							
		(1) TP Reported Guessing the Paradigm?		(2) TP wore Glasses?†		(3) TP kMMT Naïve?		(4) TP knew Practitioner?	
		Yes (n=9)	No (n=11)	Yes (n=4)	No (n=16)	Yes (n=13)	No (n=7)	Yes (n=8)	No (n=12)
(A) Emotionally-Arousing Stimuli†	Mean	0.719	0.561	0.647	0.629	0.611	0.672	0.574	0.672
	95% CI	0.588 - 0.850	0.442 - 0.681	0.281 - 1.000	0.530 - 0.727	0.495 - 0.727	0.498 - 0.847	0.463 - 0.684	0.536 - 0.807
	p -value	0.06		0.89		0.50		0.22	
	p -value compared to Chance†	**0.01***	0.28	0.29	**0.01***	0.06	0.05	0.16	**0.02***
(B) Affect-Neutral Stimuli‡	Mean	0.729	0.601	0.761	0.633	0.612	0.745	0.636	0.674
	95% CI	0.533 - 0.926	0.498 - 0.703	0.505 - 1.000	0.517 -0.749	0.493 - 0.731	0.541 - 0.950	0.461 - 0.811	0.535 - 0.813
	p -value	0.21		0.24		0.21		0.70	
	p -value compared to Chance†	**0.03***	0.05	**<0.05***	**0.03***	0.06	**0.03***	0.11	**0.02***

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; † Combined Emotional Arousal Scores > 9.8; ‡ Combined Emotional Arousal Scores <= 9..8; * Reached Significance.

6.4.3.3 Correlation Testing

Like previous studies, this study did not find any significant correlations between kMMT accuracy and the Practitioner demographics of age, number of years in practice, number of years practising kMMT, and usual number of hours per day using kMMT (see Table 6.10). Also, there was no significant correlation between kMMT accuracy and TP age (r = 0.1102, p=0.65).

TABLE 6.10 – Correlations (*r*) among kMMT accuracies and Practitioner demographics. p(2-tailed)<0.05

	kMMT Accuracy by Stimuli:	
Practitioner Demographic	**Emotionally-Arousing**	**Affect-Neutral**
Age (years)	0.0702	0.1656
p-values	*0.77*	*0.49*
Years in Practice	-0.0772	-0.0519
p-values	*0.75*	*0.83*
Years Practicing kMMT	-0.0663	0.0261
p-values	*0.78*	*0.91*
Hours/day use kMMT	0.1238	0.0527
p-values	0.60	0.83

kMMT, kinesiology-style Manual Muscle Testing

As one may anticipate, there was a significant positive correlation between kMMT accuracies using only emotionally-arousing stimuli and kMMT accuracy using only affect-neutral stimuli (see Table 6.11 and Appendix Figure B.6.3) That is, if a Pair scored high with emotionally-arousing stimuli, they seemed to score high with affect-neutral stimuli, and/or vice versa. Also, this study found that kMMT accuracy using only affect-neutral stimuli was significantly and positively correlated to a change in Practitioner's Confidence in Own kMMT Ability (Post– minus Pre–testing; p=0.01). No other significant relationship was detected between kMMT accuracy and any other Confidence score using either emotionally-arousing stimuli or affect-neutral stimuli (see Table 6.11).

Finally, in this study also, Practitioner Subjective State Anxiety showed no obvious relationship to kMMT accuracy using either emotionally-arousing stimuli or affect-neutral stimuli (see Appendix Figures B.6.3.T & U). Further analysis of this relationship revealed correlation coefficients which were insignificant (emotionally-arousing stimuli: r = -0.1153, p= 0.63; affective-neutral stimuli: r = -0.1543; p= 0.52).

TABLE 6.11 - The change in confidence ratings and correlations (r; with p-values) among kMMT accuracies and Participant confidence scores. p(2-tailed)<0.05.

	1.	2.	3.	4.	5.	6.
1. The difference in Practitioner's confidence in own kMMT ability: Post- minus Pre-testing	1.0000					
2. The difference in Practitioner's confidence in kMMT in general: Post- minus Pre-testing *p-value*	0.2673 *0.25*	1.0000				
3. The difference in Test Patient's confidence in kMMT in general: Post- minus Pre-testing *p-values*	0.1070 *0.65*	0.2095 *0.38*	1.0000			
4. The difference in Test Patient's confidence in his Practitioner: Post- minus Pre-testing *p-values*	-0.1864 *0.43*	0.1777 *0.45*	0.2926 *0.21*	1.0000		
5. The difference in Test Patient's confidence in his Practitioner's kMMT ability: Post- minus Pre-testing *p-values*	-0.1382 *0.56*	-0.0376 *0.87*	0.3928 *0.09*	0.3839 *0.09*	1.0000	
6. kMMT Accuracy using just Emotionally-Arousing Stimuli *p-values*	0.3172 *0.17*	-0.1767 *0.46*	-0.1512 *0.52*	-0.0698 *0.77*	0.0279 *0.91*	1.0000
7. kMMT Accuracy using just Affect-Neutral Stimuli *p-values*	0.5703 *0.01*	0.0209 *0.93*	0.0236 *0.92*	-0.1267 *0.59*	0.0455 *0.85*	0.8119 *<0.01*

kMMT, kinesiology-style Manual Muscle Testing;
= kMMT Accuracy correlations; = Correlation (r) which reached significance (p<0.05).

6.5 Discussion

6.5.1 Statement of Principal Findings

There were a number of unique findings from this study, plus many of the previous findings were supported by this study. The main finding was that the use of emotionally-arousing stimuli did *not* improve mean kMMT accuracy scores. In fact, the mean kMMT accuracy using only emotionally-arousing stimuli was *less* than the mean kMMT accuracy using only affect-neutral stimuli, but their difference did not reach significance. Furthermore, using only emotionally-arousing stimuli, the mean kMMT accuracy was not significantly different from Intuition either. One interesting result was that regardless of valence of stimuli (i.e. affect-neutral, emotionally-arousing, or both combined), kMMT accuracy was consistently found to be significantly better than Chance.

In addition, findings of this study also replicated those of previous studies, in that (when using the data from all stimuli) kMMT accuracy was significantly better than Intuition and Chance at distinguishing Lies from Truth. Plus, since the mean kMMT accuracy of this study fell within the 95% CI of Study 1 (see page 75) and the mean kMMT of Study 1 fell within this study's 95% CI, this suggests that the results were indeed similar.

Using all stimuli, a mean (95% CI) sensitivity of 0.620 (0.500 - 0.740) indicated that 62% the Lies were detected, while a mean (95% CI) specificity of 0.675 (0.570 - 0.780) suggests that 68% of the Truths were detected, once again suggesting Truths were easier to detect. Separating stimuli into emotionally-arousing and affect-neutral also found mean specificities were higher than mean sensitivities, also implying Truths were easier to detect, regardless of stimuli valence.

Since the prevalence of Lies is unknown in real clinical settings, it was fixed at 0.50 overall, 0.53 for emotionally-arousing stimuli and 0.48 for affect-neutral stimuli (see 2x2 Tables in Appendix Table B.6.2). The kMMT PPV and NPV for all stimuli, emotionally-arousing stimuli and affect-neutral stimuli were all analogous, ranging only from 0.641 to 0.675, indicating that roughly 2/3 of the time, the result of a kMMT could be depended upon in this study. Although these results are similar to the findings of previous studies in this series, since PPV and NPV vary with prevalence, the predictive values reported here should not be applied universally.[106]

Once again, since these methods were powered for a sample size of n=20, I am cautious about assessing the credibility of any subgroup analysis.[142] However, the following participant characteristics were found to have no influence on kMMT accuracy:

- Emotional arousal score of stimuli
- Practitioner profession
- Practitioner's number of years in practice
- Practitioner's number of years practising kMMT
- Practitioner's usual number of hours/day using kMMT
- Practitioner's kMMT technique(s) used
- Practitioner's current practising status
- Practitioner age
- TP age
- Practitioner's gender
- TP's gender
- Pair's sameness of gender

- TP's handedness
- If the TP reporting guessing the paradigm
- If the TP wore glasses during testing
- If the TP was kMMT-naïve
- If the TP knew their paired practitioner
- Any TP confidence rating
- All but one (1) Practitioner confidence rating
- Practitioner's subjective anxiety, or
- Block of testing (Late vs. Middle vs. Early in the testing)

This failure to detect any factor that consistently impacts kMMT accuracy is consistent with the findings of previous studies.

6.5.2 Strengths and Limitations

Similar to previous studies, the main strengths include the heterogeneity of sample, the use of a true gold standard as a reference standard, and its simple but robust methodology, while limitations include its lack of similarity to a true clinical setting and generalisability to other applications of kMMT. Another limitation of this study was the sample size may not have allowed for meaningful subgroups analyses.

One aspect of this study that could have been improved is the type of lie that TPs were asked to tell. In previous studies, TPs were asked to tell lies about affect-neutral stimuli (i.e. pictures and words), so in this study, some of the stimuli were exchanged for emotionally-arousing ones, with the expectation that the stress response would be enhanced, making it easier for kMMT to distinguish Lies from Truth. Nevertheless, because kMMT accuracy was

not influenced by valence of stimuli, this one change may not have been sufficient to invoke a change in kMMT accuracy. O'Sullivan et al. found that police professionals were more successful at detecting high-stakes lies than low-stakes lies.[181] She defines a high-stakes lie as a lie that has personal relevance or that is important to the liar, such as a strongly held opinion or about a highly stressful personal event or one which had a significant consequence (positive or negative). On the other hand, she defined a low-stakes lie as one that is relatively trivial, such as a "white lie," or one where the reward or punishment is immaterial. Therefore, I believe this current study would have been strengthened if the lies that the TPs were asked to tell were personally relevant to the TP.

6.5.3 Possible Explanations of Results

Using emotionally-arousing stimuli did not achieve kMMT accuracies that were any better or worse than using affect-neutral stimuli. There are 2 possible general explanations for this result: (1) that the arousal valence of stimuli actually does not influence kMMT accuracy, or (2) that the arousal valence of stimuli actually does influence kMMT accuracy, and this study did not detect the difference. Moreover, there may be a number of valid explanations for each of these 2 possibilities.

First, regarding the former, it might be that, contrary to my study hypothesis, the degree of emotional arousal of the stimuli is not a factor that affects kMMT accuracy. The TPs spoke Lies and Truths about pictures they viewed on a computer screen. It may be that it is not the *valence* of the picture being presented that is important, but how *personally relevant* the Lie is to the TP that may be a mediator.[181] Alternatively, it may be some other characteristic of the Lie that has a more intense impact on kMMT accuracy than personal relevance. Either of

these, I believe, is a more plausible justification of the results of this study than the latter reason.

Regarding the latter reason, in my view, in the unlikely event that it is correct, there are again 2 possible scenarios: Arousal valence of the stimuli does influence kMMT accuracy, either (1) positively or (2) negatively – and these study methods did not detect it. By positively, I mean using emotionally-arousing stimuli improves kMMT accuracy, and by negatively, I mean using emotionally-arousing stimuli worsens or reduces kMMT accuracy.

If using emotionally-arousing stimuli does have an impact on kMMT accuracy, positively or negatively, then perhaps this study may have had methodological problems which led to this failure to detect. For instance, this study may have been underpowered to detect the difference, or the prevalence of Lies chosen for this study was suboptimal, hindering detection of any difference. It is interesting to notice that kMMT accuracy was consistently 3-6% lower when using emotionally-arousing stimuli than when using affect-neutral stimuli (however, these differences never reached significance; see Table 6.3). On the other hand, if using emotionally-arousing stimuli does *negatively* influence kMMT accuracy, this might represent the opposite of my original hypothesis. In this instance, it could be that emotionally-arousing stimuli did cause stress in the TP, which made it more difficult, not easier, for the Practitioner to perform accurate kMMT. The reasons for this, then, might be either that this stress caused a neuromuscular aberration which resulted in inconsistent kMMT outcomes, or that the Practitioner sensed this extra stress in the TP which resulted in him feeling extra stress himself, which negatively affected his kMMT accuracy. Regardless, I am unconvinced that using emotionally-arousing stimuli impacts kMMT accuracy negatively, or at all.

6.5.4 Implications for clinical practice

From the results of this study, two recommendations for clinical practice surfaced. Firstly, I suggest that kMMT practitioners have their own kMMT accuracies assessed, because knowing their sensitivities and specificities would inform them if they are more accurate for truths or for lies. Each can then use this information to adapt his kMMT sessions accordingly. That is, if a practitioner knows he is more accurate with lies, he can introduce proportionately more lies during a session. Second is something that just occurred to me, regardless of it being a recurrent result. It is commonly thought that learning kMMT is a clinical skill, and as such is learned just like any other clinical skill (e.g. taking blood pressure readings, taking a spinal radiograph, or performing an otoscopic exam). However, the results of this study, just as in previous studies of this series, suggest that length or extent of clinical experience with kMMT did not correlate with kMMT accuracy. So, new practitioners and potential practitioners should be encouraged by this, and not disheartened if it seems like they are performing it inadequately – because it probably is not so.

In addition, this study supported the findings of previous studies in this series, in that once again it demonstrated that rigorous methodology does exist that can consistently estimate the diagnostic accuracy of kMMT for distinguishing lies from truth.

6.5.5 Unanswered questions and future research

Having just suggested to new practitioners that practice experience is not an influencer of kMMT accuracy, I feel that I must say that one of the most important targets of future kMMT research must still be to ascertain what factors promote more accurate kMMT. It still intrigues me that kMMT accuracy scores can range from 20% correct to 100% correct within a small sample of 20 Pairs. I cannot help but wonder what features does the 100% accurate

Pair possess that the 20% accurate Pair does not – and vice versa. Also, it would be interesting to know if these characteristics are innate or are acquired (i.e. learned).

Instead of focusing on the valence of the stimuli, future studies may want to compare kMMT accuracy using personally-relevant and high-stakes lies to kMMT accuracy using low-stakes, irrelevant lies, such as those used in previous studies. Researchers may want to use a multi-prong approach toward devising high-stake lies: (1) by using highly stressful, personal events, and/or (2) by amplifying the value of the reward and/or the severity of the punishment, and/or (3) by a combination of both.[181] If using high-stakes lies does turn out to improve the accuracy of kMMT, then if a practitioner tailors the statements he asked a patient to speak so that they are personally-relevant, I speculate that his accuracy score may improve.

6.6 Summary

This study repeated Study 2 using a mixture of emotionally-arousing stimuli and affect-neutral stimuli, and the differences in accuracies were compared. The results of this study suggest that kMMT using emotionally-arousing stimuli is no more or less accurate than kMMT using affect-neutral stimuli, contradicting my initial hypothesis. However, it was found that (using all stimuli combined) kMMT can be used with significant accuracy to distinguish lies from truths, compared to both Intuition and Chance. Furthermore, this study also failed to identify any factors that consistently influenced kMMT accuracy. The study would have been strengthened by adding personally-relevant, high-stakes lies instead of lies about emotionally-arousing stimuli. The primary limitation of this study is its lack of generalisability to other applications of kMMT. The main strengths of this study were its choice of a "gold standard" reference standard and its high degree of blinding. Finally, this

study is further evidence that a simple yet robust methodology for assessing the value of kMMT as a diagnostic tool can be developed and implemented effectively.

6.7 Chapter 6 – Study 5 – List of Tables and Figures

6.7.1 Tables

6.7.2 Figures

CHAPTER 7

Discussion

"All truth passes through three stages. First, it is ridiculed.

Second, it is violently opposed. Third, it is accepted as being self-evident."

Arthur Schopenhauer

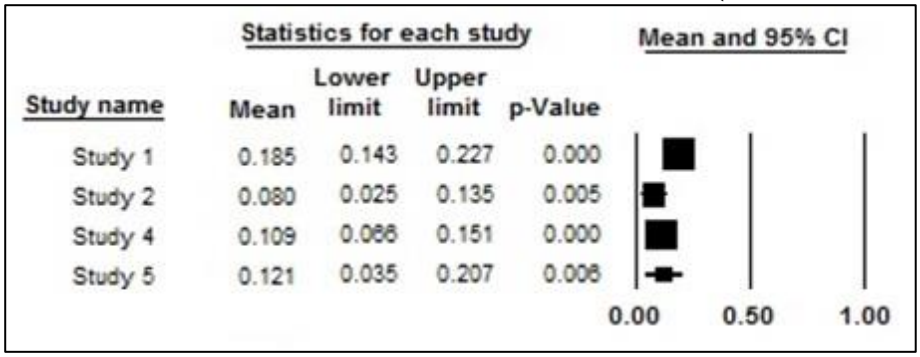
CHAPTER 7 : DISCUSSION

7.1 Statement of principal findings

A primary finding of this series of studies is that it is indeed possible to estimate the accuracy of kMMT using rigorous evidence-based scientific methodology. This has been demonstrated repeatedly by generating meaningful and useful results in which the accuracy (as overall fraction correct), sensitivity, specificity, PPV and NPV of kMMT have been calculated and compared to controlled conditions. Plus, I have used the widely-accepted standards of the STARD Statement to design, implement and analyse the results of these studies. Also following evidence-based health care standards, these studies have been reviewed and approved by ethics boards and have been registered with clinical trials registries.

Another main finding is that kMMT accuracy seems to be repetitively better than Intuition or Chance at distinguishing Lies from Truth. A summary of these results can be found in Figure 7.1, which compares the accuracy of kMMT compared to Intuition alone across Studies 1, 2, 4 and 5. [Note that Study 3 (Chapter 4) is not included because its primary outcome was not comparable to the other studies.] For similar comparisons, see also Appendix Figure B.7.1. It seems that kMMT accuracy is greater than 10% better than Intuition and can be conservatively estimated to be at least 60%. Furthermore, both the Practitioner and the TP are integral parts of the kMMT-complex, each responsible for a significant amount of the variation in accuracy, with the TP being moderately more influential.

FIGURE 7.1 – Forest Plot : Difference of the mean accuracies (kMMT – Intuition)



There were also some interesting findings regarding other measures of accuracy. For each trial the specificity was higher than the sensitivity, meaning that the proportion of Truths detected was consistently better than the proportion of Lies. This suggests that, using kMMT, truths may be easier to detect than deceit. Similarly, since the PPVs and the NPVs were consistently found in the 60%-range, it seems that (at this prevalence of Lies[i]) there is approximately a 60% chance that a weak kMMT result predicts a Lie and strong kMMT result predicts a Truth. These results parallel the aforementioned findings for the kMMT accuracy estimation. Furthermore, despite the consistently wide variation, the accuracy of kMMT seems to be sufficiently stable within and between groups.

Other notable findings were that no participant characteristic was identified which impacted accuracy consistently, and that no correlations were found that dependably predicted accuracy. In fact, even intuitiveness did not seem to correlate, nor did the blindness of the practitioner[ii]. Therefore, what influences kMMT accuracy remains wholly unknown. However, the outcome of a kMMT appears not to be the result of an ideomotor effect, as some propose.[116, 131] Furthermore, since the blindness of the practitioner[ii] did not impact kMMT accuracy, this seems to suggest practitioner were unable to be persuaded to bias the muscle test.

7.2 Strengths and limitations

A main strength of this series of studies is the rigorousness of the methods, such as high degrees of blinding, high adherence to procedures, and increased rigour as series progressed. Examples of the increased rigour include the degrees of blinding improved and my potential

[i] In all studies, the prevalence of Lies was held relatively constant around 0.50.
[ii] "... blindness of the practitioner..." – whether the Practitioner was blind to the verity of the TP's spoken statement, or not, did not seem to influence kMMT accuracy (see Chapter 2, page 80).

influence was removed. Other strengths of this series include the clearly defined target condition,[187] which enabled the use of an objective reference standard (i.e. an error-free reference standard, a true gold standard).[188] Another strength was the inclusion of a secondary index test (i.e. Intuition) as a comparator. Other noteworthy strengths were the heterogeneity of the samples (both the Practitioners and TPs), including those with varied kMMT experience and backgrounds, and a high degree of blinding.

A limitation of these studies is the lack of generalisability to other applications of kMMT. Tempting as it is to speculate, firm caution is advised against over-generalising. Another limitation is that kMMT was only compared to Intuition and Chance, and not to other tests used to distinguish Lies from Truth, such as polygraph. In addition, a limitation of this series is that these studies may have been underpowered to identify factors or characteristics that may influence or predict kMMT accuracy. A final limitation is that this series of studies did not ascertain if kMMT is clinically useful, or if a 60% accuracy is "good enough" in a clinical context.

7.3 Comparison of results to other studies

Prior to completion of this series of studies, evidence in support of kMMT and AK-MMT as valid diagnostic tests was weak and confusing, despite various attempts at their validation dating back to the 1970s.[6, 14, 25, 30-39, 49, 55, 58, 60, 90, 94, 143, 151, 164, 176-179, 189-201] The confusion about the usefulness of these tests seems to stem from the uncertainty about what methods of evaluation to employ and how best to minimise bias.[73, 202] Since the evaluation of diagnostic tests appreciably lags behind that of treatments, the quality of the reporting of diagnostic techniques has yet to catch up.[46, 66, 71, 73] With the development of the STARD Checklist, the

methods for designing and implementing evaluations of diagnostic procedures, including those of chiropractic and other CAM[iii] interventions, will undoubtedly mature as well.[66]

While detecting deceit may be of interest to some CAM practitioners, it is more widely thought of to be a topic of concern in the field of forensic science. Typically, polygraph equipment is used in criminal investigations and in employment and security screenings, by monitoring a subject's physiological changes, such as heart rate, respiratory rate, palmar sweating, brain activity, vocal changes, facial expressions, and body language.[203] In a statement by the National Research Council (2003), the polygraph is reported to produce accuracies (as overall fractions correct) ranging from 69% to 82%[iv], a range comparable to that of kMMT established in this series of studies.[203, 204] Yet, also similar to kMMT, "... (the polygraph) continues to be the subject of a great deal of scientific and public controversy..."[204]

It also might be useful to compare the accuracy results obtained in this series to estimated accuracies of other commonly-used dichotomous diagnostic tests. To do this, I have chosen a number of comparator studies with similar sample sizes and populations.[111, 202] For instance, with a sample of 72 participants, Sutlive et al.[205] evaluated the predictive validity of FABER's Test, used by chiropractors, physiotherapists and orthopaedists for diagnosing hip osteoarthritis (OA). They found this test had a sensitivity (95% CI) of 57% (34-77%) and a specificity (95% CI) of 71% (56-82%). Similarly, using a sample size of 40, Youdas et al.[206] found that another dichotomous hip OA test, Trendelenburg's Sign[v], has a sensitivity of 55%

[iii] CAM, Complementary and Alternative Medicine
[iv] No error statistics were provided in this report, which causes one to question its rigour. Also, these studies generally employed high-stakes lies, which are thought to produce higher lie detection accuracy than low-stakes lies [O'Sullivan M, Frank MG, Hurley CM, Tiwana J. Police lie detection accuracy: The effect of lie scenario. *Law and Human Behavior* 2009; 33(6):530-38.]
[v] Trendelenburg's Sign & Kinetic Finger Wiggle : also taught to and commonly-used by chiropractors.

and a specificity of 70% (no CIs reported[iv]). Likewise, Kerr et al.[207] investigated the diagnostic accuracy of visual field testing on a 172 patients (332 eyes), and found that a test called Kinetic Finger Wiggle[v] had an overall sensitivity (95% CI) of 39.0% (28.4-50.4%) and an overall specificity (95% CI) of 97.2 (90.2-99.7%) in detecting visual field deficits. In light of this evidence, it is helpful to know that the estimation of kMMT diagnostic accuracy found in this series of studies is aligned with accuracy estimations of other diagnostic tests used by similar professionals.

7.4 Implications for clinical practice

The direct implications that these results have on clinical practice are limited. However, one implication is that they may serve to heighten the confidence that clinicians have in kMMT[vi]. Another implication for clinical practice is that since specificity was consistently better than sensitivity, for improved accuracy clinicians may wish to use a majority of true statements, rather than false.

The accuracy of kMMT used in the context of these studies was found to be 60 to 70%. Practically speaking, in regard to diagnostic tests, one is inclined to ask the question: *How good is good enough?* Conventionally, this will depend upon a number of factors, such as the prevalence of the target condition, the gravity of the target condition, whether the test is being used to rule a condition in or out, and the importance of a false positive compared to a false negative.[106] The truth of the matter is there is no one accuracy statistic that fits all situations, nor is there no one hard-and-fast rule for interpreting these statistics.[73, 111]

[vi] As they did for me: My confidence in my own kMMT ability in clinical practice has grown as a result of undertaking this line of research.

So is 60% correct "good enough" for kMMT? This still remains to be seen, as the true value of a diagnostic test ultimately lies in how it impacts patient outcomes.[76]

7.5 Unanswered questions and future research

This report describes some first steps taken to estimate kMMT accuracy; however there are clearly still large gaps in the literature, ranging from specifically about the use of kMMT in the same context employed in this series of studies, to broader questions about kMMT's clinical utility.

Specifically, I found myself asking these questions: *What factors (if any) influence kMMT accuracy? Is it possible for accuracy to improve? Is it necessary for accuracy to improve? What are potential sources of variability? Would kMMT accuracy change if the paradigm were reversed*[vii]*? What if different target conditions and/or population/s were chosen? How does kMMT accuracy using other muscles compare? What would happen if the TPs were completely blind as well? And is this even possible??*

With knowledge about factors that can influence accuracy, it may be possible to maximise and stabilise kMMT accuracy to a point where it may be more universally clinically dependable. On the other hand, it is unclear if improved accuracy is a prerequisite for improving patient health.[76]

Additionally, research is needed to assess the usefulness of kMMT for detecting other commonly-used target conditions, such as the need for nutritional supplementation[190] or in the identification of an allergy or hypersensitivity or toxicity.[32, 90, 191, 208] In the past, muscle testing failed to successfully identify these conditions;[34-36, 90, 94, 95, 137, 190, 191, 209-212] however,

[vii] Reversed paradigm: Truth ⟶ weak; Lie ⟶ strong.

in many of these studies strict evidence-based health care protocols may not have been rigorously applied, and methodologies in general were vague.

Future research in the diagnostic usefulness of kMMT should employ rigorous methods, including: (1) a clear and specific research objective, (2) a well-defined target condition, (3) explicit outcomes that are easy to interpret, (4) an appropriate sample of the target population (who were objectively selected), (5) an objective reference standard, (6) an adequate sample size, and (7) appropriate blinding.[202]

On the other hand, it might not be as simplistic as this. It could be that CAM researchers are trying to evaluate muscle testing using an allopathic yardstick, which may not be appropriate.[213] An example of this may be with allergies. The medical approach of the diagnosis of an allergy is commonly through a skin prick test or a blood test of the IgE antibody.[214] However, it is questionable if these are appropriate measures for a CAM perspective. In any case, the design of future diagnostic accuracy studies using kMMT for other target conditions must be given in-depth and broad-minded consideration.

One might be tempted to suggest to future researchers to explore the mechanism/s of action of kMMT, that is, to explore *how kMMT works*[viii]. Making such a suggestion is beyond the scope of an evidence-based health care approach. This question falls more the realm of researchers in the basic sciences.

Finally, and most importantly, kMMT's true clinical value must be explored.[73, 76, 84, 117, 215, 216] Toward this end, the efficacy of kMMT technique systems must be investigated via

[viii] *"How does muscle testing work?"* is a question I get asked repeatedly. However, the ones asking this question are usually chiropractors or other muscle testing practitioners, and not research scientists, such as my colleagues in my department. If there is one thing I learned through this process, it is that clinical researchers are mainly concerned IF a test or an intervention works, and not HOW it works: If it works, then does it really matter how?

rigorously-designed randomised, controlled trials (RCTs). For example, future researchers could compare the effectiveness of a naturopathic approach for irritable bowel syndrome using two groups of naturopaths: (1) those that use kMMT to guide treatment (e.g. to prescribe supplementation and offer dietary advice), and (2) those who do not use kMMT. Another question that future researchers may want to explore is how effective are alternative emotional healing techniques, such as HeartSpeak[ix], for such conditions as depression, panic attacks or obsessive compulsive disorder, compared to traditional psychological approaches, such as cognitive behavioural therapy.

Finally, aside from health-related quality of life queries, it will also be important for future researchers to consider another aspect of clinical utility: Does using kMMT lead to more efficient use of health care resources?[73]

7.6 Summary

kMMT has repeatedly been found to be significantly more accurate than both Intuition and Chance, for one application of this common assessment method: distinguishing lies from truths. Practitioners appear to be an integral part of the kMMT dynamic yet factors that contribute or detract from its effectiveness could not be identified. A limitation of this series of studies is a lack of generalisability to other applications of kMMT. Another limitation is that with these results it is not ascertained if 60% correct is "good enough" in a clinical context. Additionally, future investigators may want to explore kMMT accuracy to detect other target conditions and in different population/s, and what factors (if any), such as Practitioner and TP characteristics, influence kMMT accuracy. However, improved accuracy may not result in improved patient outcomes. Therefore, an important next step in

[ix] www.HeartSpeak.me

establishing the validity of kMMT is assessing its clinical utility within kMMT technique systems as a whole through effectiveness trails.

No test is perfect: 100% accurate, easy to use, risk-free and low cost.[202, 217] However, the results of this series of studies are encouraging. It is hoped that this report will urge practitioners, researchers and health policy makers to explore kMMT, as a potential method of assessment and patient management.

7.7 Chapter 7 – List of Tables and Figures

7.7.1 Figures

APPENDICES

"An important scientific innovation rarely makes its way by gradually winning over and converting its opponents: What does happen is that the opponents gradually die out."

Max Planck

APPENDIX A

Participant Forms

“There's a world of difference between truth and facts. Facts can obscure the truth.”

Maya Angelou

APPENDIX A : PARTICIPANT FORMS

Participant Information Sheet (PIS) / Informed Consent : Studies 1,2,4,5

page 1 of 2

Muscle Testing Study

We invite you to take part in a study developed jointly through Parker Research Institute, Parker College of Chiropractic, and the University of Oxford, UK.

Purpose
The purpose of this study is to investigate the accuracy of manual muscle testing with healthy adults under varying conditions.

Procedures
If you agree to join this study you will fill out 2 questionnaires which will take about 5 minutes to complete. You have the right to refuse to answer any question. *What will be expected of you?*

Volunteer Practitioners: You will be asked to perform manual muscle testing on another volunteer. Also, you may be viewing pictures on a computer screen. You will be testing the volunteer's deltoid muscle (lateral or anterior) in response to spoken statements, and entering your findings into a computer.

Volunteer Patients: You will be having manual muscle testing performed on you in response to specific stimuli. For instance, you will be viewing pictures on a computer screen and you will be told what to say in relation to the picture. Some stimuli will be neutral, and some may be emotionally arousing. Your shoulder muscle will be tested after you speak the cued statement. You will be asked to resist the downward pressure that the practitioner will be applying.

Risks/Discomforts
Manual muscle testing is a non-invasive assessment tool. However, some muscle fatigue and discomfort are experienced when performing manual muscle testing. Please advise the principal investigator if this occurs. Also, some of the pictures you may be viewing may be emotionally arousing – positively or negatively. If you experience any undue stress and as a result wish to stop your participation, you are free to do so at any time.

Benefits
Since this study is testing the accuracy of a commonly-used assessment only, and involves no intervention, there are no direct benefits to participants.

Voluntary Participation: Your participation in this study is *voluntary*. You may remove yourself from the study for any reason at any time by contacting the Principle Investigator. No reimbursement of costs is possible in this study.

Participant Information Sheet (PIS) / Informed Consent : Studies 1,2,4,5

page 2 of 2

Investigators Benefits

Your principal investigator is not being remunerated to conduct this study. There is no conflict of interest to compromise their position or this research study.

Confidentiality of Records: You will be assigned a number which will identify your individual case. All records which identify you by name will be kept private. Your name will not be available to individual(s) other than those conducting the study. In any report we publish or present, we will not include information that will make it possible to identify you as a participant.

Questions Regarding this Study: Please tell the Principle Investigator, or your Research Assistant, if you have any questions about this research study. Both the Oxford Tropical Research Ethics Committee (OxTREC Ref # 41-10) and the Parker University Institutional Review Board for Human Subjects have reviewed and approved this study. If you have questions later or wish to withdraw from the study, please contact her at 214-500-0584, or email: anne.jensen@wolfson.ox.ac.uk.

We will give you a copy of this form to keep for your records.

Statement of Consent

I,_____, have read the above information
(Print Name Here)
and all my questions have been addressed. I freely and voluntarily consent to participate in this study.

Signature:_____Date:_____

Participant Information Sheet (PIS) / Informed Consent : Study 3

page 1 of 2

Muscle Testing Study

We invite you to take part in a study developed jointly through Parker Research Institute, Parker College of Chiropractic, and the University of Oxford, UK.

Purpose
The purpose of this study is to investigate the accuracy of manual muscle testing with healthy adults under varying conditions.

Procedures
If you agree to join this study you will fill out 2 questionnaires which will take about 5 minutes to complete. You have the right to refuse to answer any question. *What will be expected of you?*

You will be performing grip strength testing in response to specific stimuli. For instance, you will be viewing pictures on a computer screen and you will be told what to say in relation to the picture. After you speak the cued statement you will squeeze the grip strength dynamometer as hard as you can for several seconds. And you will be alternating hands after every 5 tests.

Risks/Discomforts
Grip strength testing is a non-invasive assessment tool. However, some muscle fatigue and discomfort may be experienced during the testing. Please advise the principal investigator if this occurs. Also, some of the pictures you may be viewing may be emotionally arousing – positively or negatively. If you experience any undue stress and as a result wish to stop your participation, you are free to do so at any time.

Benefits
Since this study is testing the accuracy of a commonly-used assessment only, and involves no intervention, there are no direct benefits to participants.

Voluntary Participation: Your participation in this study is *voluntary*. You may remove yourself from the study for any reason at any time by contacting the Principle Investigator. No reimbursement of costs is possible in this study.

Illness or Injury
The investigators believe that there are no risks of illness or injury from participation in this study. If, nonetheless, you believe that you became ill or were injured as a result of being in this study, please contact your medical doctor and the principle investigator.

Participant Information Sheet (PIS) / Informed Consent : Study 3

page 2 of 2

Investigators Benefits

Your principal investigator is not being remunerated to conduct this study. There is no conflict of interest to compromise their position or this research study.

Confidentiality of Records: You will be assigned a number which will identify your individual case. All records which identify you by name will be kept private. Your name will not be available to individual(s) other than those conducting the study. In any report we publish or present, we will not include information that will make it possible to identify you as a participant.

Questions Regarding this Study: Please tell the Principle Investigator, or your Research Assistant, if you have any questions about this research study. Both the Oxford Tropical Research Ethics Committee (OxTREC Ref # 41-10) and the Parker University Institutional Review Board for Human Subjects have reviewed and approved this study. If you have questions later or wish to withdraw from the study, please contact her at 214-500-0584, or email: anne.jensen@wolfson.ox.ac.uk.

We will give you a copy of this form to keep for your records.

Statement of Consent

I,_____, have read the above information
(Print Name Here)
and all my questions have been addressed. I freely and voluntarily consent to participate in this study.

Signature:_____Date:_____

Practitioner Instruction Sheet : Study 1

page 1 of 2

Practitioner

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your investigator before beginning. *Thank you!*

Before the test begins, be sure you have completed the following forms:

1. Please complete the Consent Form and the Demographics Form
2. Please remove all watches and bracelets

The Muscle Test:

- You will be testing the Testee's Anterior Deltoid or Lateral Deltoid. See Figure 1 for an example.
- You may chose to test either the ***right*** arm or the ***left*** arm of the Testee. Once you have decided which arm to test, please *only* use this arm.
- You may use any style of muscle testing you prefer (see Figure 1 for an example), but again, once you have decided on your style, please *only* use this style during all testing. NOTE: If your Testee fatigues, s/he may unknowingly change positions – ***watch for this!***
- Position the Testee so that you are face-to-face and so that you are not able to see each other's computer monitors.

Figure 1 – Muscle Testing Example

Preliminary Information:

- You will be muscle testing congruent and incongruent statements. They are defined as follows:
  - A ***congruent*** statement is one which the speaker believes to be ***true***.
  - An ***incongruent*** statement is one which the speaker believes to be ***false***.
- ***Prior research*** has found that a muscle test following a congruent statement resulted in a "strong" muscle response, and a muscle test following an incongruent statement resulted in a "weak" muscle response. To summarise:
  - Congruent Statement → Muscle stayed "STRONG"
  - Incongruent Statement → Muscle went "WEAK"

  This is the paradigm we will be using during this study. If you have any questions about this, or if this is unclear, please consult with your investigator prior to commencing.
- **Practice:** Prior to starting the actual testing, please perform several ***practice*** muscle tests to gauge the strength required. Have the Testee say statements such as these:
  - *"My name is (insert Testee's name)."*
  - *"My name is (insert either 'Ralph' or 'Ethel' – or some name other than the Testee's)."*
  - *"I live in the United States."*
  - *"I live in Russia."*

NOTE: Please do *NOT* disclose the paradigm we are testing: *Congruent → Strong; Incongruent → Weak*

- When muscle testing during this study, there will only be two possible results: STRONG or WEAK. You must decide which category the result was in. *("I don't know" is not a choice!!)*
- You will be muscle testing statements spoken by the Testee. These statements will be referring to pictures that the Testee will be viewing on a computer monitor. Similarly, you will be viewing pictures on another computer monitor. The pictures you view will be either the ***same*** as the Testee's **OR** your screen will be ***BLANK*** (black).

Participant Instruction Sheet – Practitioner : Study 1

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Practitioner

- The order of pictures and statements has been randomly computer generated. As a result, you may get runs of BLANKS – this is okay.
- After you have performed each muscle test and determined if the Testee's muscle stayed "strong" or went "weak," please record your findings using the keyboard provided: Press the letter "S" if the arm stayed "STRONG," and press the letter "W" if the arm went "WEAK." Pressing the "W" or "S" keys will advance to the next picture (or blank screen).
- You will be muscle testing a series of statements and recording the result of each test yourself.
- Only do ***one*** muscle test per spoken statement, however you may ask the Testee to repeat the statement as often as necessary. In other words, if you need to re-check, ask the Testee to repeat the statement:
- The statements will be broken up into blocks of 10. There will be 6 Testing blocks and 6 "Resting" blocks. Following each Testing block there will be a Resting block, where the Testee can rest his/her arm.
- During the Resting blocks, the Testee will also speak statements in regards to pictures; however, during these blocks, you will not be muscle testing. You will simply listen and then record whether you think the Testee spoke a Congruent Statement ("C") or an Incongruent Statement ("I"): Press the letter "C" if you think the Testee was Congruent with the statement spoken, and press the letter "I" if you think the Testee was Incongruent with the statement spoken. Pressing the "C" or "I" keys will advance to the next picture (or blank screen).
- Also, there will be a number from 1 to 10 in the bottom right-hand corner of the screen. This number corresponds to the statement number in each block. The numbers should advance from 1 to 10 for each block. They are there so you can keep track of where you are within the block.
- Please do not speak the result of any test or decision, or discuss the result with him/her (e.g. "That went weak."). *This is important!*

The Testing:

For each of the Testing repetitions:

1. Take your muscle testing positions.
2. Then you each advance the computer monitor to the first picture.
3. The Testee will then say a statement out loud, and you will immediately perform the muscle test.
4. You alone will decide if the arm stayed "STRONG" or went "WEAK."
5. Record the result ("S" for "STRONG" or "W" for "WEAK") by pressing the appropriate letter on the keyboard for each repetition.

For each of the Resting repetitions:

1. You will follow the same basic procedure as during the Testing repetitions, except you will be instructed where to place your hands: On your own knee, or on the Testee's wrist or arm.
2. When the Testee says a statement out loud, and you will make your best guess if the Testee was "CONGRUENT" or "INCONGRUENT" with the statement s/he spoke. Again *you alone will decide.*
3. Record the result ("C" for "CONGRUENT" or "I" for "INCONGRUENT") by pressing the appropriate letter on the keyboard for each repetition.

Final Notes:

- If at any time, you or your Testee feels fatigued or needs a rest, please rest for up to two (2) minutes. *Please do not change arms or positions at any stage of testing! This is not allowed, but you will be given ample time to rest if need be.*
- Please do not discuss the details of your experiences here today with other study participants or potential participants.
- Thank you for your time today – we greatly appreciate your participation!

Participant Instruction Sheet – Test Patient : Study 1

page 1 of 2

Test Patient – Study I

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your assistant before beginning. *Thank you!*

Before the test begins:

1. Please complete the Consent Form and the Pre-testing Questionnaire.
   NOTE: You may not be able to answer some questions on the Questionnaire until after meeting your Practitioner! This is okay. You will get a chance to finish before the testing begins.
2. Please take off watches and bracelets

General Information:

- Today a Practitioner (who is also a study participant) will be testing your shoulder muscles in response to statements you will say out loud.
- See Figure 1 for an example of how the Practitioner might be testing you.
- Your Practitioner may ask you to stand or to sit during the testing. Please follow his or her instructions.
- Your Practitioner will choose to test either your ***right*** arm or your ***left*** arm. If you have a preference, please tell your Practitioner ***before*** beginning.
- During the muscle test, keep your arm straight, with your elbow ***locked***, at the height and position your Practitioner will tell you.

Figure 1 - Muscle Testing Example

- Your Practitioner will place his / hand somewhere on your arm or wrist.
- During the muscle test, the Practitioner will press down on your arm and you are to resist his/her downward pressure. Do not worry if you cannot resist this pressure, but please ***do*** tell your Practitioner if you are feeling discomfort in any way.
- Before the actual testing begins, your Practitioner will perform a number of practice tests. S/He will ask you to say a specific statement and will test your muscle response to this statement. These practice tests will help him/her gauge your muscle strength and keep the pressure within your comfort level.
- In front of you will be a computer monitor that is attached to a mouse and an earpiece. You will be viewing pictures on the monitor and hearing instructions through the earpiece. You will also be asked to use the mouse, so position yourself comfortably to do so, but in the way your Practitioner has instructed you, and so that s/he cannot see your monitor.
- Place the earpiece in one ear ***only***, and place the mouse within easy reach.
- Your Practitioner will be viewing the ***same pictures as you*** on a his/her computer monitor and will have a keyboard instead of a mouse.
- During the actual testing phase, your Practitioner will be testing a series of statements you will say out loud. The statements will be broken up into blocks of 10 statements each. There will be 6 Testing blocks and 6 "Resting" blocks. Following each Testing block there will be a Resting block, where you can rest your arm.
- During the Resting blocks, you will also speak statements in reference to pictures; however, during these blocks, the Practitioner will not be muscle testing, but may be touching your arm.
- Also, there will be a number from 1 to 10 in the bottom right-hand corner of the screen. This number corresponds to the statement number in each block. The numbers should advance from 1 to 10 for each of the blocks. They are there so you can keep track of where you are within the block.
- To advance to the next picture/statement, press the LEFT MOUSE BUTTON of your mouse – but only ***after*** your Practitioner is finished testing and had advanced his/her screen. *This is important!!*

Participant Instruction Sheet – Test Patient : Study 1

page 2 of 2

- If you do not remember or did not hear the instructions, press the RIGHT MOUSE BUTTON – this will repeat the last instructions.
- During the testing, your Practitioner will *not* be reviewing with you the results of these muscle tests. Please do not ask him/her for the results. Please do not voice your opinion about the results, or speak anything other than your statement. However, if you notice something during the testing or resting, please remember this – you will have a chance to let us know about it at the end.
- Sometimes you will be asked to "lie" or say something that is untrue. For instance, you may be viewing an apple on the monitor, but you may be instructed to say, "I see a tomato." Try to remain as neutral as possible. *This is important!!*
- The pictures and statements presented to you will be randomly chosen by the computer. As a result, you may get runs of true statements or runs of false statements in a row – this is okay.

The Testing:

For each of the Testing repetitions:

1. You each advance your computer monitors to the first picture and look at them. At no time will you allow your Practitioner to see your monitor.
2. When your picture is displayed, you will also hear an audio cue (via your earpeice) instructing you what to say. For instance, you may hear, "Say, 'I see a ball.'" Please remember these instructions.
3. Your Practitioner will then ask you to put your arm in the muscle testing position.
4. When in testing position ***and while looking at your monitor***, you will say what you were instructed to say. ***Please look at your monitor while speaking the statement!***
5. Your Practitioner will then immediately perform the muscle test by pressing on your arm.
6. After the test is complete, get ready to advance the computer monitor to the next picture. But only advance to the next picture ***after*** your Practitioner does! *This is important!!*

For each of the Resting repetitions:

1. You will follow the same basic procedure as during the Testing repetitions, except your Practitioner will not be muscle testing you; however, s/he may be touching your wrist or your arm.

Final Notes:

- Once you have finished, there will be on final questionnaire, the Post-testing Questionnaire.
- If at any time, you feel fatigued or need a rest, please tell your Practitioner and/or your research assistant immediately. *However, please do not ask to change arms – this is not allowed, but you will be given ample opportunity to rest, if need be.*
- Please do not discuss the details of your experiences here today with other study participants or potential participants.
- Thank you for your time today – we greatly appreciate your participation!

Participant Instruction Sheet - Practitioner : Studies 2,5

page 1 of 2

Practitioner

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your investigator before beginning. *Thank you!*

Before the test begins, be sure you have completed the following forms:

1. Please complete the Consent Form and the Demographics Form
2. Please remove all watches and bracelets

The Muscle Test:

- You will be testing the Test Patients Anterior Deltoid or Lateral Deltoid. See Figure 1 for an example.
- You may chose to test either the ***right*** arm or the ***left*** arm of the Test Patient. Once you have decided which arm to test, please ***only*** use this arm.
- You may use any style of muscle testing you prefer (see Figure 1 again for an example), but again, once you have decided on your style, please ***only*** use this style during all testing. NOTE: If your Test Patient fatigues, s/he may unknowingly change positions – ***watch for this!***
- Position the Test Patient so that you are face-to-face and so that you are not able to see his/her computer monitor.

Figure 1 – Muscle Testing Example

Preliminary Information:

- You will be muscle testing congruent and incongruent statements. They are defined as follows:
  - A ***congruent*** statement is one which the speaker believes to be ***true***.
  - An ***incongruent*** statement is one which the speaker believes to be ***false***.
- ***Prior research*** has found that a muscle test following a congruent statement resulted in a "strong" muscle response, and a muscle test following an incongruent statement resulted in a "weak" muscle response. To summarise:
  - Congruent Statement → Muscle stayed "STRONG"
  - Incongruent Statement → Muscle went "WEAK"

  This is the paradigm we will be using during this study. If you have any questions about this, or if this is unclear, please consult with your investigator prior to commencing.
- **Practice:** Prior to starting the actual testing, please perform several ***practice*** muscle tests to gauge the strength required. Have the Test Patient say statements such as these:
  - *"My name is (insert Test Patient's name)."*
  - *"My name is (insert either 'Ralph' or 'Ethel' – or some name other than the Test Patient's)."*
  - *"I live in the United States."*
  - *"I live in Russia."*

NOTE: Please do ***NOT* disclose the paradigm we are testing: *Congruent → Strong; Incongruent → Weak***

- When muscle testing during this study, there will only be two possible results: STRONG or WEAK. You must decide which category the result was in. *("I don't know" is not a choice!!)*
- You will be muscle testing statements spoken by the Test Patient. These statements will be referring to pictures that the Test Patient will be viewing on a computer monitor.
- The order of pictures and statements will be randomly computer generated. As a result, there may be runs of TRUE or FALSE statements – this is okay.

Participant Instruction Sheet – Practitioner : Studies 2, 5

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Practitioner

- After you have performed each muscle test and determined if the Test Patient's muscle stayed "STRONG" or went "WEAK," please record your findings using the keyboard provided: Press the letter "S" if the arm stayed "STRONG," and press the letter "W" if the arm went "WEAK." Pressing the "W" or "S" keys will advance to the next picture/statement.
- You will be muscle testing a series of statements and recording the result of each test yourself.
- Only do ***one*** muscle test per spoken statement, however you may ask the Test Patient to repeat the statement as often as necessary. In other words, if you need to re-check, ask the Test Patient to repeat the statement.
- The statements will be broken up into blocks of 10. Following each Testing block there will be a Resting block, where the Test Patient can rest his/her arm.
- During the Resting blocks, the Test Patient will also speak statements in regards to pictures; however, during these blocks, you will not be muscle testing. You will simply listen and "guess" if you think the Test Patient spoke a Congruent Statement ("C") or an Incongruent Statement ("I"): Press the letter "C" if you think the Test Patient was Congruent with the statement spoken, and press the letter "I" if you think the Test Patient was Incongruent with the statement spoken. Pressing the "C" or "I" keys will advance to the next picture/statement.
- Please do not speak the result of any test or decision, or discuss the result with him/her (e.g. "That went weak."). *This is important!*

The Testing:

For each of the Testing repetitions:

1. Take your muscle testing positions.
2. Then advance the computer to the first picture.
3. The Test Patient will then say a statement out loud, and you will immediately perform the muscle test.
4. You alone will decide if the arm stayed "STRONG" or went "WEAK."
5. Record the result ("S" for "STRONG" or "W" for "WEAK") by pressing the appropriate letter on the keyboard for each repetition.

For each of the Resting repetitions:

1. You will follow the same basic procedure as during the Testing repetitions, except you will be instructed where to place your hands: On your own knee, or on the Test Patient's wrist or arm.
2. When the Test Patient says a statement out loud, and you will make your best guess if the Test Patient was "CONGRUENT" or "INCONGRUENT" with the statement s/he spoke. Again y*ou alone will decide.*
3. Record the result ("C" for "CONGRUENT" or "I" for "INCONGRUENT") by pressing the appropriate letter on the keyboard for each repetition.

Final Notes:

- If at any time, you or your Test Patient feels fatigued or needs a rest, please rest for up to two (2) minutes. *Please do not change arms or positions at any stage of testing! This is not allowed, but you will be given ample time to rest if need be.*
- Please do not discuss the details of your experiences here today with other study participants or potential participants.
- Thank you for your time today – we greatly appreciate your participation!

Participant Instruction Sheet – Test Patient : Studies 2,5

page 1 of 2

Test Patient

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your assistant before beginning. *Thank you!*

Before the test begins:

1. Please complete the Consent Form and the Demographics Form
   NOTE: You may not be able to answer some questions on the Demographics Form until after meeting your Practitioner! This is okay. You will get a chance to finish before the testing begins.
2. Please take off watches and bracelets

General Information:

Figure 1 - Muscle Testing Example

- Today a Practitioner (who is also a study participant) will be testing your shoulder muscles in response to statements you will say out loud.
- See Figure 1 for an example of how the Practitioner might be testing you.
- Your Practitioner may ask you to stand or to sit during the testing. Please follow his or her instructions.
- Your Practitioner will choose to test either your ***right*** arm or your ***left*** arm. If you have a preference, please tell your Practitioner ***before*** beginning.
- During the muscle test, keep your arm straight, with your elbow ***locked***, at the height and position your Practitioner will tell you.
- Your Practitioner will place his / hand somewhere on your arm or wrist.
- During the muscle test, the Practitioner will press down on your arm and you are to resist his/her downward pressure. Do not worry if you cannot resist this pressure, but please ***do*** tell your Practitioner if you are feeling discomfort in any way.
- Before the actual testing begins, your Practitioner will perform a number of practice tests. S/He will ask you to say a specific statement and will test your muscle response to this statement. These practice tests will help him/her gauge your muscle strength and keep the pressure within your comfort level.
- In front of you – and behind the Practitioner – will be a computer monitor that is attached to a mouse and a headset. You will be viewing pictures on the monitor and hearing instructions through the headset. You will also be asked to use the mouse, so position yourself comfortably to do so, but in the way your Practitioner has instructed you.
- Place the headset on and place the mouse within easy reach.
- During the actual testing phase your Practitioner will be testing a series of statements you will say out loud. The statements will be broken up into blocks of 10 statements each. Following each Testing block there will be a Resting block, where you can rest your arm.
- During the Resting blocks, you will also speak statements in reference to pictures; however, during these blocks, the Practitioner will not be muscle testing, but may be touching you.

Participant Instruction Sheet – Test Patient : Studies 2, 5

page 2 of 2

Test Patient

- If you do not remember or did not hear the instructions, press the RIGHT MOUSE BUTTON or BACKSPACE key – this will repeat the last statement.
- During the testing, your Practitioner will *not* be reviewing with you the results of these muscle tests. Please do not ask him/her for the results. Please do not voice your opinion about the results, or speak anything other than your statement. However, if you notice something during the testing or resting, please remember this – you will have a chance to let us know about it at the end.
- Sometimes you will be asked to "lie" or say something that is untrue. For instance, you may be viewing an apple on the monitor, but you may be instructed to say, "I see a tomato." Try to remain as neutral as possible. *This is important.*
- The order of pictures and statements presented to you will be randomly chosen by the computer. As a result, you may get runs of true statements or runs of false statements in a row – this is okay.

The Testing:

For each of the Testing repetitions:

1. At no time will you allow your Practitioner to see your monitor.
2. When your picture is displayed, you will also hear an audio cue (via your headset) instructing you what to say. For instance, you may hear, "Say, 'I see a ball.'" Please remember these instructions.
3. Your Practitioner will then ask you to put your arm in the muscle testing position.
4. When in testing position ***and while looking at your monitor***, you will say what you were instructed to say. ***Please look at your monitor while speaking the statement!***
5. Your Practitioner will then immediately perform the muscle test by pressing on your arm.

For each of the Resting repetitions:

1. You will follow the same basic procedure as during the Testing repetitions, except your Practitioner will not be muscle testing you; however, s/he may be touching your wrist or your arm.

Final Notes:

- If at any time, you feel fatigued or need a rest, please tell your Practitioner and/or your research assistant immediately. *However, please do not ask to change arms – this is not allowed, but you will be given ample opportunity to rest if need be.*
- Please do not discuss the details of your experiences here today with other study participants or potential participants.
- Thank you for your time today – we greatly appreciate your participation!

Participant Instruction Sheet : Study 3 – Grip Strength

page 1 of 1

Test Patient

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your assistant before beginning. *Thank you!*

Before the test begins:

1. Please complete the Consent Form and the Demographics Form
2. Please take off watches, bracelets and rings

Figure 1 - Grip Strength Dynamometer

General Information:

- Today we will be testing your grip strength in response to statements you will say out loud.
- We will be using a grip strength dynamometer during testing (Figure 1), and we will be testing both hands (alternating).
- Before the actual testing begins, you will have a chance to practice with the dynamometer.
- You will be seated comfortably in front a computer screen with an earpiece in our ear to hear the instructions.
- During the testing, keep your elbow bent to 90 degrees and at your side. ***This is important!!***
- We will be starting with your dominant hand (the one you write with) and ending with your other hand.
- During the testing, the statements will be broken up into blocks of 5 statements each, and each hand will be tested 20 times. At the end of each Testing block you will switch hands.
- If you do not remember or did not hear the instructions, press the BACKSPACE key – this will repeat the last statement.
- Once you hear the instructed statement, squeeze the dynamometer as hard as you can ***for 5 seconds***.
- The investigator will then record your score by entering it into the computer. Then the next picture/statement will appear.
- Sometimes you will be asked to "lie" and sometimes to tell the truth. Just please do as you are instructed.
- The order of pictures and statements presented to you will be randomly chosen by the computer. As a result, you may get runs of true statements or runs of false statements in a row – this is okay.

The Testing:

For each of the Testing repetitions:

1. Hold the dynamometer in the hand being tested. Keep your elbow bent to a right angle (90°) and at your side.
2. When your picture is displayed, you will also hear an audio cue (via your headset) instructing you what to say. For instance, you may hear, "Say, 'I see a ball.'" Please remember these instructions.
3. Then ***while looking at your monitor***, say what you were instructed to say. ***Please look at your monitor while speaking the statement!***
4. Then immediately squeeze the dynamometer ***as hard as you can*** ("maximum effort") ***for 5 seconds.***
5. Then get ready for the next picture / statement.

After 5 repetitions, you will be prompted to switch hands. Please do so when prompted.

Final Notes:

- If at any time, you feel fatigued or need a rest, please tell your Investigator immediately. *However, please do not ask to change hands – this is not allowed, but you will be given ample opportunity to rest if need be.*
- Please do not discuss the details of your experiences here today with other study participants or potential participants.
- Thank you for your time today – we greatly appreciate your participation!

Participant Instruction Sheet – Practitioner : Study 4

page 1 of 2

Practitioner - IV

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your investigator before beginning. *Thank you!*

Before the test begins, be sure you have completed the following forms:

1. Please complete the Consent Form and the Demographics Form thoroughly!
2. Please remove all watches and bracelets

The Muscle Test:

- You will be testing all Test Patients' Anterior Deltoid or Lateral Deltoid. See Figure 1 for an example.
- For each Test Patient, you may choose to test either the ***right*** arm or the ***left*** arm. Once you have decided which arm to test, please *only* use this arm. You may switch arms for each Test Patient.
- You may use any style of muscle testing you prefer (see Figure 1 again for an example), but again, once you have decided on your style, please *only* use this style during all testing. NOTE: If any Test Patient fatigues, s/he may unknowingly change positions – ***watch for this!***
- Position each Test Patient so that you are face-to-face and so that you are not able to see his/her computer monitor.

Figure 1 – Muscle Testing Example

Preliminary Information:

- You will be muscle testing congruent and incongruent statements. They are defined as follows:
  - A ***congruent*** statement is one which the speaker believes to be ***true***.
  - An ***incongruent*** statement is one which the speaker believes to be ***false***.
- ***Prior research*** has found that a muscle test following a congruent statement resulted in a "strong" muscle response, and a muscle test following an incongruent statement resulted in a "weak" muscle response. To summarise:
  - Congruent Statement → Muscle stayed "STRONG"
  - Incongruent Statement → Muscle went "WEAK"

  This is the paradigm we will be using during this study. If you have any questions about this, or if this is unclear, please consult with your investigator prior to commencing.
- **Practice:** Prior to starting the actual testing, please perform several ***practice*** muscle tests to gauge the strength required. Have the Test Patient say statements such as these:
  - *"My name is (insert Test Patient's name)."*
  - *"My name is (insert either 'Ralph' or 'Ethel' – or some name other than the Test Patient's)."*
  - *"I live in the United States."*
  - *"I live in Russia."*

NOTE: Please do *NOT* disclose the paradigm we are testing: *Congruent → Strong; Incongruent → Weak*

- When muscle testing during this study, there will only be two possible results: STRONG or WEAK. You must decide which category the result was in. *("I don't know" is not a choice!!)*
- You will be muscle testing statements spoken by the Test Patient. These statements will be referring to pictures that the Test Patient will be viewing on a computer monitor.
- The order of pictures and statements will be ***randomly*** generated by the computer. As a result, there may be runs of TRUE or FALSE statements – this is okay.

Participant Instruction Sheet – Practitioner : Study 4

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Practitioner - IV

- After you have performed each muscle test and determined if the Test Patient's muscle stayed "STRONG" or went "WEAK," please record your findings using the keyboard provided: Press the letter "S" if the arm stayed "STRONG," and press the letter "W" if the arm went "WEAK." Pressing the "W" or "S" keys will advance to the next picture/statement. ***NOTE****: Pressing any other key besides "S" or "W" will do nothing!*
- You will be muscle testing a series of statements and recording the result of each test yourself.
- Only do ***one*** muscle test per spoken statement, however you may ask the Test Patient to ***repeat*** the statement as often as necessary. In other words, if you need to re-check, ask the Test Patient to repeat the statement.
- The statements will be broken up into blocks of 10. Following each Testing block there will be a Resting Block, where the Test Patient can rest his/her arm.
- During the Resting blocks, the Test Patient will also speak statements in regards to pictures; however, during these blocks, you will not be muscle testing. You will simply listen and "guess" if you think the Test Patient spoke a Congruent Statement ("C") or an Incongruent Statement ("I"): Press the letter "C" if you think the Test Patient was Congruent with the statement spoken, and press the letter "I" if you think the Test Patient was Incongruent with the statement spoken. Pressing the "C" or "I" keys will advance to the next picture/statement. ***NOTE****: Pressing any other key besides "C" or "I" will do nothing!*
- Please do not speak aloud the result of any test or decision, or discuss the result with him/her (e.g. "That went weak" or "Did that stay strong?"). *This is important!*
- There will be 2 Testing Blocks and 2 Resting / Guessing Blocks per Test Patient.

The Testing:

For each of the Testing Blocks:

1. Take your muscle testing positions.
2. Then advance the computer to the first picture.
3. The Test Patient will then say a statement out loud, and you will immediately perform the muscle test.
4. You alone will decide if the arm stayed "STRONG" or went "WEAK."
5. Record the result ("S" for "STRONG" or "W" for "WEAK") by pressing the appropriate letter on the keyboard for each repetition.
6. 1 Testing Block = 10 statements / muscle tests. There will be 2 Testing Blocks per Test Patient.

For each of the Resting Blocks:

1. You will follow the same basic procedure as during the Testing Blocks, except instead of muscle testing, you will place your hand on the Test Patient's wrist or forearm – which will be resting on his/her knee.
2. When the Test Patient says a statement out loud, and you will make your ***best guess*** if the Test Patient was "CONGRUENT" or "INCONGRUENT" with the statement s/he spoke. Again, y*ou alone will decide*.
3. Record the result ("C" for "CONGRUENT" or "I" for "INCONGRUENT") by pressing the appropriate letter on the keyboard for each repetition.
4. 1 Resting / Guessing Block = 10 statements / guesses. There will be 2 Resting / Guessing Blocks per Test Patient.

Final Notes:

- If at any time, you or your Test Patient feels fatigued or needs a rest, please rest for up to two (2) minutes. *Please do not change arms or positions at any stage of testing! This is not allowed, but you will be given ample time to rest if need be.*
- Until all data collection is completed tonight, please do not discuss the details of your experiences with other study participants or potential participants.
- Thank you for your time – we greatly appreciate your participation!

Participant Instruction Sheet – Test Patient : Study 4

page 1 of 2

Test Patient - IV

Instructions Sheet

Please read these instructions and follow them to the best of your ability. If anything is unclear, please ask your investigator before beginning. *Thank you!*

Before the test begins:

1. Please complete the Consent Form and the Demographics Form
   NOTE: There are no "right" answers – just put what you think!
2. Please take off watches and bracelets

General Information:

- Today a series of Practitioners (who are also study participants) will be testing your shoulder muscles in response to statements you will say out loud.
- See Figure 1 for an example of how a Practitioner might test you.
- Each Practitioner may ask you to stand or to sit during the testing. Please follow his or her instructions.
- Each Practitioner will choose to test either your ***right*** arm or your ***left*** arm. If you have a preference, please tell him or her ***before*** beginning.
- During the muscle test, keep your arm straight, with your elbow ***locked***, at the height and position your Practitioner will tell you.

Figure 1 - Muscle Testing Example

- Each Practitioner will place his / hand somewhere on your arm or wrist.
- During the muscle test, the Practitioner will press down on your arm and you are to resist his/her downward pressure. Do not worry if you cannot resist this pressure, but please ***do*** tell the Practitioner if you are feeling discomfort in any way.
- Before the actual testing begins, the Practitioner will perform a number of practice tests. S/He will ask you to say a specific statement and will test your muscle response to this statement. These practice tests will help him/her gauge your muscle strength and keep the pressure within your comfort level.
- In front of you will be a computer monitor that is attached to a earpiece. You will be viewing pictures on the monitor and hearing instructions through the earpiece. Position yourself comfortably, but in the way your Practitioner has instructed you.
- Place the earpiece in one ear. Only one (not both) please. The volume may have to be adjusted for your comfort.
- During the actual testing phase the Practitioner will be testing a series of statements you will say out loud. The statements will be broken up into blocks of 10 statements each. Following each Testing Block there will be a Resting Block, where you can rest your arm.
- During the Resting Blocks, you will also speak statements in reference to pictures; however, during these blocks, the Practitioner will not be muscle testing, but will be touching your arm.
- There will be 2 Testing Blocks and 2 Resting Blocks for each Practitioner.

Participant Instruction Sheet – Test Patient : Study 4

page 2 of 2

Test Patient - IV

- During the testing, the Practitioners will not be reviewing with you the results of these muscle tests. Please do not ask him/her for the results. Please do not voice your opinion about the results, or speak anything other than your statement. However, if you notice something during the testing or resting phases, please remember this – you will have a chance to let us know about it at the end.
- Sometimes you will be asked to "lie" or say something that is untrue. For instance, you may be viewing an apple on the monitor, but you may be instructed to say, "I see a tomato." Try to remain as neutral as possible (e.g. use a "Poker Face"). *This is important!*
- The order of pictures and statements presented to you will be randomly chosen by the computer. As a result, you may get runs of true statements or runs of false statements in a row – this is okay.

The Testing:

For each of the Testing Blocks:

1. At no time will you allow any Practitioner to see your monitor.
2. When your picture is displayed, you will also hear an audio cue (via your earpiece) instructing you what to say. For instance, you may hear, "Say, 'I see a ball.'" Please remember these instructions.
3. The Practitioner will then ask you to put your arm in the muscle testing position.
4. When in testing position ***and while looking at your monitor***, you will say what you were instructed to say. ***Please look at your monitor while speaking the statement!***
5. The Practitioner will then immediately perform the muscle test by pressing on your arm.
6. The Practitioner then will advance to the next picture/statement by pressing a key on his/her keyboard.
7. 1 Testing Block = 10 pictures / statements / muscle tests. There will be 2 Testing Blocks per Practitioner.

For each of the Resting repetitions:

1. You will follow the same basic procedure as during the Testing Blocks, except the Practitioner will not be muscle testing you; however, s/he will be touching your wrist or arm.
2. Again, the Practitioner will advance to the next picture/statement by pressing a key on his/her keyboard.
3. 1 Resting Block = 10 pictures / statements. There will be 2 Resting Blocks per Practitioner.

Final Notes:

- If at any time, you feel fatigued or need a rest, please tell the Practitioner and/or your research assistant immediately. *However, please do not ask to change arms – this is not allowed, but you will be given ample time to rest if need be.*
- Until all the data is collected tonight, please do not discuss the details of your experiences here today with other study participants or potential participants.
- Thank you for your time today – we greatly appreciate your participation!

Pre-Testing Questionnaire – Practitioner : Studies 1,2,5

page 1 of 1

Practitioner

Confidential Participant Information

Surname _____ First Name(s)_____

Sex: ☐ Female ☐ Male Age _____ Today's Date _____

Profession: _____ Years in Profession: _____

Are you currently practicing? ☐ No ☐ Yes – if so: ☐ Full time ☐ Part time

Length of muscle testing experience (years + months): _____years_____months

In the last 6 mos, how many hrs/day (ave.) do you use muscle testing/week? _____

MMT Technique/s you use: _____

Do you use this type of muscle testing? ☐ Yes, currently ☐ No, but I have ☐ No, never

Which hand of ***yours*** do you mainly use for muscle testing? R L Both Equal

Rank your own level of muscle testing expertise: (None=0, Expert=4) 0 1 2 3 4

Rate the confidence you have in ***your own ability*** to muscle test: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the confidence you have in ***muscle testing in general***: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Would you like to learn the results of this study? No Yes

If yes, please provide postal or email address: _____

_____

Please write any comments or concerns on back of page.

Pre-Testing Questionnaire – Test Patient : Studies 1,2,5

page 1 of 1

Test Patient

Confidential Participant Information

Last Name _____ First Name(s)_____

Sex: ☐ Female ☐ Male Age _____ Date _____

Handedness: R-handed L-Handed Do you know your Practitioner? No Yes

Do you wear glasses? No Yes

Rate the confidence you have in muscle testing in general: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the general level of confidence you have in your Practitioner: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the confidence you have in your Practitioner's muscle testing ability: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

If you would you like to learn the results of this study please provide postal or email address: _____

Please write any comments or concerns below or on back of page.

Pre-Testing Questionnaire – Test Patient : Study 3

page 1 of 1

Test Patient

Confidential Participant Information

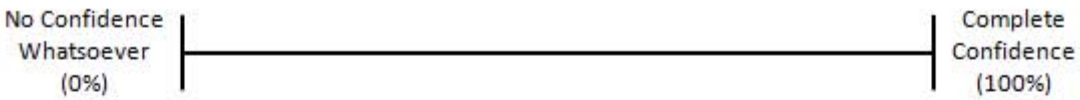
Last Name _____ First Name(s)_____

Sex: ☐ Female ☐ Male Age _____ Date _____

Handedness: R-handed L-Handed Do you wear glasses? No Yes

Do you have any prior muscle testing experience? No Yes

Rate the confidence you have in muscle testing in general: (Mark with a '|')



If you would you like to learn the results of this study please provide postal or email address: _____

Please write any comments or concerns below or on back of page.

Pre-Testing Questionnaire – Practitioner : Study 4

page 1 of 1

Practitioner

Confidential Participant Information

Name _____

Sex: ☐ Female ☐ Male Age _____ Today's Date _____

Profession: _____ Years in Practice: _____

Are you currently practicing? ☐ No ☐ Yes – if so: ☐ Full time ☐ Part time

Length of muscle testing experience (years + months): _____years _____months

Of late, how many hours per day (on average) do you use muscle testing? _____

MMT Technique/s you use: AK TBM NET CRA CK PSYCH-K PKP NOT

NeuroLink BodyTalk Touch for Health Other/s:_____

Specific muscle/s you routinely use for MMT (e.g. Anterior Deltoid, Iliopsoas, etc):

_____

Dominant Hand: R L Which arm of ***yours*** will you be using today? R L

Rank your own level of muscle testing expertise: (None=0, Expert=4) 0 1 2 3 4

Rate the confidence you have in ***your own ability*** to muscle test: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the confidence you have in ***muscle testing in general***: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

If you would you like to learn the results of this study please provide postal or email address: _____

Please write any comments or concerns on back of page.

Pre-Testing Questionnaire – Test Patient : Study 4

page 1 of 1

Test Patient - IV

Confidential Participant Information

Name _____ Date _____

Sex: ☐ Female ☐ Male Age _____

Handedness: R-handed L-Handed

Will you be wearing glasses during the testing? No Yes

Rate your own level of personal experience with muscle testing: (Mark with a '|')

No Experience Whatsoever — A Great Deal Of Experience

Rate the confidence you have in muscle testing in general: (Mark with a '|')

No Confidence Whatsoever (0%) — Complete Confidence (100%)

Rate the amount of anxiety you are experiencing *right now*: (Mark with a '|')

No Anxiety Whatsoever — Worst Anxiety Ever

If you would you like to learn the results of this study please provide postal or email address: _____

Please write any comments or concerns below or on back of page.

Post-Testing Questionnaire – Practitioner : All Studies

page 1 of 1

Practitioner

Post-testing Questionnaire

Name _____ Date _____

Rate the confidence you have in ***your own ability*** to muscle test: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the confidence you have in ***muscle testing in general***: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the confidence you have in ***THIS*** type of muscle testing: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate your confidence in your own ability to muscle test THIS Testee: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Please write any comments or concerns or anything you noticed during the testing or resting phases: (You may also use the back of this page.)

Post-Testing Questionnaire – Test Patient : All Studies

page 1 of 1

Test Patient

Post-testing Questionnaire

Name _____ Date _____

Did you wear glasses during the testing? No Yes

Rate the confidence you have in muscle testing in general: (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the general level of confidence you have in your Practitioner (if applicable): (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Rate the confidence you have in your Practitioner's muscle testing ability (if applicable): (Mark with a '|')

No Confidence Whatsoever (0%) —— Complete Confidence (100%)

Did you notice anything about the testing after TRUE statements compared to FALSE statements?

_____

_____

Please write any comments or concerns or anything you at all noticed: (You may also use the back of this page.)

_____

_____

_____

Practitioner Score Sheets : Study 4 – Reproducibility & Repeatability

page 1 of 2

Practitioner Name _____ **Practitioner #** _____

PRE-Test Questions – Please respond to each question *after* you've met and practiced with each Test Patient but *before* the actual testing has begun. If you are asked for a rating, use a rating scale of 0 to 10, with 0 being lowest/none and 10 being high or "a lot." *These are YOUR opinions only!*		**Test Patient #**						
		1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**
1.	Rate how well you know this patient (0=Not at all; 10=extremely well):							
2.	Rate (0 to 10) your level of confidence in your ability to Muscle Test this Test Patient:							
3.	Rate (0 to 10) this Test Patient's "willingness" to be muscle tested (0=not willing; 10= extremely willing):							
4.	Rate (0 to 10) how much you "like" this Test Patient:							
5.	Rate (0 to 10) how much "connection" you feel with this Test Patient:							
6.	Rate (0 to 10) your current level of Anxiety:							

Practitioner Score Sheets : Study 4 – Reproducibility & Repeatability

page 2 of 2

POST-Test Questions – Please respond to each question *after* you've completed all the actual testing for each Test Patent but *before* you've met the next one. If you are asked for a rating, use a rating scale of 0 to 10, with 0 being lowest/none and 10 being high or "a lot"). *These are YOUR opinions only!*		**Test Patient #**						
		1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**
1.	Estimate your Muscle Testing accuracy (% correct) for this Test Patient to the nearest 5% (That is, answer the question: "I think my muscle testing was _____% correct.")							
2.	Estimate your Guessing accuracy (% correct) for this Test Patient to the nearest 5% (That is, answer the question: "I think my guessing was _____% correct.")							
3.	Rate (0 to 10) your level of confidence in your ability to Muscle Test this Test Patient:							
4.	Rate (0 to 10) this Test Patient's "willingness" to be muscle tested (0=not willing; 10= extremely willing):							
5.	Rate (0 to 10) how much you "like" this Test Patient:							
6.	Rate (0 to 10) how much "connection" you feel with this Test Patient:							
7.	Rate (0 to 10) your current level of Anxiety:							

COMMENTS: _____

_____

_____

_____

_____

Test Patient Score Sheets : Study 4 – Reproducibility & Repeatability

page 1 of 2

Test Patient Name _____ **Test Patient #** _____

PRE-Test Questions – Please respond to each question *after* you've met each Practitioner and *before* the actual testing has begun. If you are asked for a rating, use a rating scale of 0 to 10, with 0 being lowest/none and 10 being high / "a lot." *These are YOUR opinions only!*	**PRACTITIONER #**								
	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**
1. Rate how well you know this Practitioner (0=Not at all; 10=extremely well):									
2. Rate (0 to 10) your level of confidence in this Practitioner in general:									
3. Rate (0 to 10) your level of confidence in this Practitioner's muscle testing ability:									
4. Rate (0 to 10) how much you "like" this Practitioner:									
5. Rate (0 to 10) how much "connection" you feel with this Practitioner:									
6. Rate (0 to 10) your current level of Anxiety:									

PRE-Test Questions – Please respond to each question *after* you've met each Practitioner and *before* the actual testing has begun. If you are asked for a rating, use a rating scale of 0 to 10, with 0 being lowest/none and 10 being high / "a lot." *These are YOUR opinions only!*	**PRACTITIONER #**								
	10.	**11.**	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**
1. Rate how well you know this Practitioner (0=Not at all; 10=extremely well):									
2. Rate (0 to 10) your level of confidence in this Practitioner in general:									
3. Rate (0 to 10) your level of confidence in this Practitioner's muscle testing ability:									
4. Rate (0 to 10) how much you "like" this Practitioner:									
5. Rate (0 to 10) how much "connection" you feel with this Practitioner:									
6. Rate (0 to 10) your current level of Anxiety:									

Test Patient Score Sheets : Study 4 – Reproducibility & Repeatability

page 2 of 2

POST-Test Questions – Please respond to each question after you've met each Practitioner and before the actual testing has begun. If you are asked for a rating, use a rating scale of 0 to 10, with 0 being lowest/none and 10 being high or "a lot." *These are <u>YOUR</u> opinions only!*	**PRACTITIONER #**								
	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**
1. Rate (0 to 10) your level of confidence in this Practitioner in general:									
2. Rate (0 to 10) your level of confidence in this Practitioner's muscle testing ability:									
3. Rate (0 to 10) how much you "like" this Practitioner:									
4. Rate (0 to 10) how much "connection" you feel with this Practitioner:									
5. Estimate this Practitioner's Muscle Testing accuracy (% correct) to the nearest 5% (e.g. 85% correct):									

POST-Test Questions – Please respond to each question after you've met each Practitioner and before the actual testing has begun. If you are asked for a rating, use a rating scale of 0 to 10, with 0 being lowest/none and 10 being high or "a lot." *These are <u>YOUR</u> opinions only!*	**PRACTITIONER #**								
	10.	**11.**	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**
1. Rate (0 to 10) your level of confidence in this Practitioner in general:									
2. Rate (0 to 10) your level of confidence in this Practitioner's muscle testing ability:									
3. Rate (0 to 10) how much you "like" this Practitioner:									
4. Rate (0 to 10) how much "connection" you feel with this Practitioner:									
5. Estimate this Practitioner's Muscle Testing accuracy (% correct) to the nearest 5% (e.g. 85% correct):									

COMMENTS: _____

_____

APPENDIX B

Extra Figures & Tables

"Fast is fine, but accuracy is everything."

Wyatt Earp

APPENDIX B : EXTRA FIGURES & TABLES : CONTENTS

List of Extra Figures & Tables

Chapter 1 – Background

Chapter 2 – Study 1

Chapter 3 – Study 2 (Replication of Study 1)

Chapter 4 – Grip Strength Study

Chapter 5 – Reproducibility Study

Chapter 6 – Emotional Stimuli Study

APPENDIX TABLE B.6.1 - kMMT & Intuition accuracies for all statements compared to True and False statements. Using all stimuli, for n=20 Pairs.

APPENDIX TABLE B.6.2 - 2x2 Tables for kMMT for each Pair (n=20). Each Pair performed 40 kMMTs. Using (A) emotionally-arousing, and (B) affect-neutral stimuli.

APPENDIX TABLE B.6.3 - Correlations among accuracy scores. kMMT & Intuition, emotionally-arousing & affect-neutral stimuli.

APPENDIX FIGURE B.6.1 – Histograms for overall kMMT & Intuition accuracies.

APPENDIX FIGURE B.6.2 – Histograms of the distribution of (A) picture and (B) word arousal levels – showing normal distributions.

APPENDIX FIGURE B.6.3 – Scatterplots.

Chapter 7 – Discussion / Summary

APPENDIX FIGURE B.7.1 : Additional Forest Plots

CHAPTER 1

APPENDIX TABLE B.1.1 – Literature search strategy. The following search strategy was applied in [TITLE/ABSTRACT] :

1st: "kinesiology"

AND

('diagnos*' OR 'accuracy' OR 'sensitivity' OR 'specificity' OR 'precision' OR 'validity'

OR 'reproducibility' OR 'repeatability' OR 'utility' OR 'inter*examiner' OR 'inter*rater OR 'intra*examiner' OR 'intra*rater' OR 'predict*')

2nd: "kinesiology" OR "applied kinesiology"

AND

('diagnos*' OR 'accuracy' OR 'sensitivity' OR 'specificity' OR 'precision' OR 'validity' OR 'reproducibility' OR 'repeatability' OR 'utility' OR 'inter*examiner' OR 'inter*rater OR 'intra*examiner' OR 'intra*rater' OR 'predict*')

3rd: "kinesiology" OR "applied kinesiology" OR "manual muscle testing"

AND

('diagnos*' OR 'accuracy' OR 'sensitivity' OR 'specificity' OR 'precision' OR 'validity' OR 'reproducibility' OR 'repeatability' OR 'utility' OR 'inter*examiner' OR 'inter*rater OR 'intra*examiner' OR 'intra*rater' OR 'predict*')

CHAPTER 2

APPENDIX TABLE B.2.1 - 2x2 Table for kinesiology-style Manual Muscle Testing (kMMT); for each Pair (n=48). Blocks 1-4, Practitioner blind.

Pair 1		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	0	3	3
	Strong (–)	6	6	12
	Totals	6	9	15

prevalence= 0.40

Pair 2		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	3	8
	Strong (–)	6	10	16
	Totals	11	13	24

prevalence= 0.46

Pair 3		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	1	7
	Strong (–)	6	5	11
	Totals	12	6	18

prevalence= 0.67

Pair 4		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	2	5	7
	Strong (–)	2	7	9
	Totals	4	12	16

prevalence= 0.25

Pair 5		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	4	11
	Strong (–)	4	4	8
	Totals	11	8	19

prevalence= 0.58

Pair 6		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	2	0	2
	Strong (–)	2	9	11
	Totals	4	9	13

prevalence= 0.31

Pair 7		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	4	9
	Strong (–)	3	7	10
	Totals	8	11	19

prevalence= 0.42

Pair 8		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	3	10
	Strong (–)	6	4	10
	Totals	13	7	20

prevalence= 0.65

Pair 9		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	3	7
	Strong (–)	4	6	10
	Totals	8	9	17

prevalence= 0.47

Pair 10		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	3	7
	Strong (–)	3	10	13
	Totals	7	13	20

prevalence= 0.35

APPENDIX TABLE B.2.1 (con't.)

Pair 11		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	1	10
	Strong (–)	2	7	9
	Totals	11	8	19

prevalence= 0.58

Pair 12		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	1	6
	Strong (–)	6	12	18
	Totals	11	13	24

prevalence= 0.46

Pair 13		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	4	8
	Strong (–)	2	8	10
	Totals	6	12	18

prevalence= 0.33

Pair 14		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	3	10
	Strong (–)	1	5	6
	Totals	8	8	16

prevalence= 0.50

Pair 15		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	2	5
	Strong (–)	5	6	11
	Totals	8	8	16

prevalence= 0.50

Pair 16		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	1	4
	Strong (–)	6	8	14
	Totals	9	9	18

prevalence= 0.50

Pair 17		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	3	9
	Strong (–)	3	7	10
	Totals	9	10	19

prevalence= 0.47

Pair 18		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	2	8
	Strong (–)	0	5	5
	Totals	6	7	13

prevalence= 0.46

Pair 19		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	1	10
	Strong (–)	2	12	14
	Totals	11	13	24

prevalence= 0.46

Pair 20		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	0	4
	Strong (–)	2	7	9
	Totals	6	7	13

prevalence= 0.46

APPENDIX TABLE B.2.1 (con't.)

Pair 21		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	2	5
	Strong (–)	5	9	14
	Totals	8	11	19

prevalence= 0.42

Pair 22		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	1	1	2
	Strong (–)	9	9	18
	Totals	10	10	20

prevalence= 0.50

Pair 23		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	4	11
	Strong (–)	1	5	6
	Totals	8	9	17

prevalence= 0.47

Pair 24		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	10	5	15
	Strong (–)	1	4	5
	Totals	11	9	20

prevalence= 0.55

Pair 25		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	2	11
	Strong (–)	2	11	13
	Totals	11	13	24

prevalence= 0.46

Pair 26		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	8	3	11
	Strong (–)	3	7	10
	Totals	11	10	21

prevalence= 0.52

Pair 27		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	2	7
	Strong (–)	3	6	9
	Totals	8	8	16

prevalence= 0.50

Pair 28		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	3	8
	Strong (–)	2	3	5
	Totals	7	6	13

prevalence= 0.54

Pair 29		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	4	9
	Strong (–)	6	9	15
	Totals	11	13	24

prevalence= 0.46

Pair 30		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	1	5
	Strong (–)	4	8	12
	Totals	8	9	17

prevalence= 0.47

APPENDIX TABLE B.2.1 (con't.)

Pair 31		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	4	9
	Strong (–)	3	7	10
	Totals	8	11	19

prevalence= 0.42

Pair 32		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	1	5
	Strong (–)	4	7	11
	Totals	8	8	16

prevalence= 0.50

Pair 33		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	1	6
	Strong (–)	4	7	11
	Totals	9	8	17

prevalence= 0.53

Pair 34		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	10	1	11
	Strong (–)	1	12	13
	Totals	11	13	24

prevalence= 0.46

Pair 35		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	4	9
	Strong (–)	3	4	7
	Totals	8	8	16

prevalence= 0.50

Pair 36		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	0	0	0
	Strong (–)	6	7	13
	Totals	6	7	13

prevalence= 0.46

Pair 37		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	4	10
	Strong (–)	5	4	9
	Totals	11	8	19

prevalence= 0.58

Pair 38		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	8	5	13
	Strong (–)	2	5	7
	Totals	10	10	20

prevalence= 0.50

Pair 39		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	1	4
	Strong (–)	5	8	13
	Totals	8	9	17

prevalence= 0.47

Pair 40		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	5	9
	Strong (–)	7	5	12
	Totals	11	10	21

prevalence= 0.52

APPENDIX TABLE B.2.1 (con't.)

Pair 41		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	5	10
	Strong (–)	6	3	9
	Totals	11	8	19

prevalence= 0.58

Pair 42		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	2	4	6
	Strong (–)	9	9	18
	Totals	11	13	24

prevalence= 0.46

Pair 43		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	0	6
	Strong (–)	2	8	10
	Totals	8	8	16

prevalence= 0.50

Pair 44		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	3	7
	Strong (–)	2	4	6
	Totals	6	7	13

prevalence= 0.46

Pair 45		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	3	8
	Strong (–)	2	9	11
	Totals	7	12	19

prevalence= 0.37

Pair 46		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	2	5
	Strong (–)	4	7	11
	Totals	7	9	16

prevalence= 0.44

Pair 47		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	2	9
	Strong (–)	4	11	15
	Totals	11	13	24

prevalence= 0.46

Pair 48		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	2	8
	Strong (–)	3	6	9
	Totals	9	8	17

prevalence= 0.53

APPENDIX TABLE B.2.2 - kMMT & Intuition accuracies for all statements, True statements and False statements (for n=48 Pairs).

	ALL STATEMENTS			TRUE vs FALSE STATEMENTS					
				FALSE Statements			TRUE Statements		
	kMMT	Intuition	*p* -value	kMMT	Intuition	*p* -value	kMMT	Intuition	*p* -value
Mean	**0.659**	**0.474**	**<0.01***	**0.568**	**0.392**	**<0.01***	**0.734**	**0.542**	**0.01***
95% CI	0.623 - 0.695	0.449 - 0.500		0.504 - 0.633	0.334 - 0.450		0.687 - 0.782	0.480 - 0.603	
Minimum	0.400	0.238		0.000	0.000		0.375	0.000	
Maximum	0.917	0.636		1.000	1.000		1.000	1.000	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; *Significance reached

APPENDIX TABLE B.2.3 - kMMT accuracy by profession, and kMMT accuracy correlations among professions.

	Profession†						
kMMT Accuracy	**Chiropractors (DC)** (n=20)	**Mental Health Professionals (MH)** (n=4)	**Acupuncturists (Acu)** (n=2)	**Naturopaths (ND)** (n=2)	**Massage Therapists (MT)** (n=2)	**Other Health Professionals (OHP)** (n=12)	**Other Professionals Not Health (Other)** (n=4)
Mean	0.670	0.748	0.561	0.728	0.650	0.630	0.567
95% CI	0.611 - 0.729	0.534 - 0.962	-1.212 - 2.332	0.448 - 1.008	-0.458 - 1.757	0.562 - 0.697	0.389 - 0.745
Minimum	0.458	0.588	0.421	0.706	0.563	0.429	0.400
Maximum	0.917	0.875	0.700	0.750	0.737	0.846	0.632
***p*-values:**							
DC	—	—	—	—	—	—	—
MH	0.342	—	—	—	—	—	—
Acu	0.574	0.383	—	—	—	—	—
ND	0.156	0.790	0.439	—	—	—	—
MT	0.856	0.455	0.651	0.530	—	—	—
OHP	0.342	0.178	0.707	**0.0382***	0.859	—	—
Other	0.062	0.085	0.972	0.059	0.512	0.370	—

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; * Significance reached.

† Two (2) Practitioners did not respond to this question;

TABLE B.2.4 - Table of correlations among all continuous variables (*r*). (p <0.05)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1.	Practitioner's Age (years)	1.0000																													
2.	Years in Practice	0.6030	1.0000																												
3.	Years of kMMT Experience	0.5157	0.6908	1.0000																											
4.	Average Hours/day using kMMT	0.1420	0.4680	0.2748	1.0000																										
5.	Practitioner's Confidence in Own kMMT Ability - Pre-testing	0.3149	0.2657	0.5348	0.2837	1.0000																									
6.	Practitioner's Confidence in MMT in General - Pre-testing	0.0204	0.0152	0.0493	0.2143	0.3540	1.0000																								
7.	Practitioner's Confidence in Own kMMT Ability - Post-testing	-0.0309	-0.1885	0.1812	0.1023	0.5311	0.3453	1.0000																							
8.	Practitioner's Confidence in MMT in General - Post-testing	-0.2016	-0.3984	-0.2122	0.1440	0.1783	0.6572	0.5564	1.0000																						
9.	Practitioner's Confidence in kMMT in General - Post-testing	-0.1054	-0.1206	0.0168	0.1165	0.0560	0.1994	0.4585	0.2659	1.0000																					
10.	Practitioner's Confidence in Testing this TP	-0.3177	-0.3042	-0.0714	0.1708	0.1035	0.1044	0.4897	0.4271	0.5013	1.0000																				
11.	Test Patient Age (years)	0.0506	0.0632	0.0284	0.0090	-0.0181	0.1726	-0.0005	0.2185	-0.1318	-0.1248	1.0000																			
12.	TP's Confidence in kMMT in General - Pre-testing	-0.1409	-0.0131	-0.0374	-0.0674	0.0802	-0.1468	0.0458	-0.1373	0.0718	-0.1618	-0.0889	1.0000																		
13.	TP's Confidence in Paired Practitioner - Pre-testing	-0.2304	-0.1486	-0.2064	0.0598	0.0621	0.0262	0.0895	0.1170	0.1526	-0.0077	-0.2378	0.5143	1.0000																	
14.	TP's Confidence in Practitioner's kMMT - Pre-testing	-0.2145	-0.0921	-0.1188	0.0483	-0.0111	-0.0053	0.0344	0.0675	0.1460	-0.0100	-0.1751	0.5404	0.9018	1.0000																
15.	TP's Confidence in kMMT in General - Post-testing	0.0204	0.1189	0.0990	-0.0655	0.1194	-0.1376	-0.1210	-0.2193	0.0373	-0.1423	-0.0739	0.7545	0.4288	0.4713	1.0000															
16.	TP's Confidence in Paired Practitioner - Post-testing	-0.1776	0.0038	0.0485	0.2175	0.0219	-0.0890	0.0738	0.1081	0.3011	0.2498	-0.2187	0.3906	0.6652	0.6642	0.4971	1.0000														
17.	TP's Confidence in Practitioner's kMMT - Post-testing	-0.1300	0.0506	0.1174	0.2033	-0.0016	-0.1567	0.0703	0.0132	0.3003	0.2860	-0.2360	0.3842	0.5785	0.6100	0.4986	0.9691	1.0000													
18.	**MMT Accuracy (Overall Fraction Correct)**	-0.0175	-0.0080	-0.0175	-0.0133	-0.0043	-0.0811	0.0546	0.0407	-0.0788	0.0477	0.0602	0.0300	0.1290	0.0863	0.1189	0.1851	0.1639	1.0000												
19.	The Sum of Practitioner's Confidence in Own kMMT Ability: Pre- + Post-testing	0.1477	0.0251	0.3940	0.2193	0.8546	0.3989	0.8939	0.4353	0.3106	0.3549	-0.0099	0.0705	0.0877	0.0152	-0.0110	0.0568	0.0422	0.0312	1.0000											
20.	The Difference of Practitioner's Confidence in Own kMMT Ability: Pre- - Post-testing	0.3327	0.4592	0.3082	0.1986	0.3650	-0.0436	-0.5950	-0.4423	-0.4507	-0.4399	-0.0167	0.0257	-0.0395	-0.0483	0.2462	-0.0603	-0.0787	-0.0641	-0.1715	1.0000										
21.	The Sum of Practitioner's Confidence in MMT in General: Pre- + Post-testing	-0.1046	-0.2200	-0.0955	0.1950	0.2883	0.9022	0.5001	0.9180	0.2571	0.2993	0.2158	-0.1558	0.0807	0.0358	-0.1978	0.0150	-0.0749	-0.0194	0.4590	-0.2760	1.0000									
22.	The Difference of Practitioner's Confidence in MMT in General: Pre- - Post-testing	0.2761	0.5167	0.3227	0.1131	0.1845	0.3287	-0.2994	-0.4958	-0.1035	-0.4148	-0.0749	0.0029	-0.1164	-0.0907	0.1162	-0.2379	-0.1971	-0.1444	-0.0859	0.5040	-0.1108	1.0000								
23.	The Sum of ALL Practitioner's Ranked Confidences	-0.1208	-0.2081	0.0847	0.2728	0.4534	0.5815	0.8092	0.7192	0.7216	0.7137	-0.0076	-0.0552	0.1149	0.0700	-0.1062	0.2101	0.1815	-0.0119	0.7358	-0.4591	0.7175	-0.2312	1.0000							
24.	The Sum of TP's Confidence in kMMT in General: Pre- + Post-testing	-0.0651	0.0558	0.0322	-0.0713	0.1063	-0.1518	-0.0393	-0.1899	0.0584	-0.1624	-0.0870	0.9378	0.5039	0.5404	0.9354	0.4734	0.4707	0.0791	0.0322	0.1441	-0.1886	0.0630	-0.0859	1.0000						
25.	The Difference of TP's Confidence in kMMT in General: Pre- - Post-testing	-0.2317	-0.1870	-0.1939	-0.0054	-0.0534	-0.0168	0.2370	0.1124	0.0507	-0.0318	-0.0236	0.3730	0.1341	0.1116	-0.3276	-0.1404	-0.1517	-0.1248	0.1170	-0.3110	0.0555	-0.1602	0.0706	0.0276	1.0000					
26.	The Sum of TP's Confidence in Paired Practitioner: Pre- + Post-testing	-0.2304	-0.1486	-0.2064	0.0598	0.0621	0.0262	0.0895	0.1170	0.1526	-0.0077	-0.2378	0.5143	1.0000	0.9018	0.4288	0.6652	0.5785	0.1290	0.0877	-0.0395	0.0807	-0.1164	0.1149	0.5039	0.1341	1.0000				
27.	The Difference of TP's Confidence in Paired Practitioner: Pre- - Post-testing	-0.0798	-0.1913	-0.3168	-0.1674	0.0521	0.1380	0.0254	0.0194	-0.1639	-0.3047	-0.0406	0.1851	0.4713	0.3490	-0.0481	-0.3450	-0.4175	-0.0564	0.0432	0.0216	0.0837	0.1347	-0.1037	0.0742	0.3344	0.4713	1.0000			
28.	The Sum of TP's Confidence in Practitioner's kMMT: Pre- + Post-testing	-0.0944	-0.1615	-0.2674	-0.1645	-0.0107	0.1720	-0.0410	0.0612	-0.1763	-0.3361	0.0704	0.1735	0.3608	0.4359	-0.0343	-0.3510	-0.4473	-0.0887	-0.0307	0.0349	0.1255	0.1215	-0.1272	0.0753	0.2982	0.3608	0.8681	1.0000		
29.	The Difference of TP's Confidence in Practitioner's kMMT: Pre- - Post-testing	-0.2145	-0.0921	-0.1188	0.0483	-0.0111	-0.0053	0.0344	0.0675	0.1460	-0.0100	-0.1751	0.5404	0.9018	1.0000	0.4713	0.6642	0.6100	0.0863	0.0152	-0.0483	0.0358	-0.0907	0.0700	0.5404	0.1116	0.9018	0.3490	0.4359	1.0000	
30.	The Sum of ALL TP's Ranked Confidences	-0.1783	-0.0634	-0.1120	0.0003	0.0948	-0.0637	0.0352	-0.0270	0.1261	-0.0904	-0.1944	0.8156	0.8904	0.8482	0.7610	0.6651	0.6095	0.1223	0.0718	0.0513	-0.0490	-0.0395	0.0265	0.8419	0.0983	0.8904	0.3336	0.2651	0.8482	1.0000
31.	The Sum of ALL Ranked Confidences (Practitioner & TP)	-0.2070	-0.1935	-0.0134	0.1818	0.3925	0.3794	0.6108	0.5039	0.6080	0.4575	-0.1355	0.5056	0.6791	0.6183	0.4320	0.5975	0.5395	0.0732	0.5820	-0.2988	0.4880	-0.1942	0.7435	0.5009	0.1170	0.6791	0.1479	0.0851	0.6183	0.6883

kMMT, kinesiology-style manual muscle testing; TP, Test Patient; rrelation (*r*) reached significance (p <0.05); T Accuracy - no correlations (r) reached significance.

APPENDIX TABLE B.2.5 - kMMT accuracy by kMMT technique system - detailed. NOTE: Those p-values below the line may not be meaningful.

kMMT Technique System	#	kMMT Accuracy	95% CI	kMMT Accuracy Range	*p* -value Compared to Chance**
Neuro Emotional Technique (NET)	25	0.676	0.622 - 0.731	0.421 - 0.875	**<0.0001***
Applied Kinesiology (AK)	17	0.658	0.602 - 0.714	0.500 - 0.917	**<0.0001***
All Others Combined	40	0.652	0.610 - 0.695	0.400 - 0.875	**<0.0001***
Total Body Modification (TBM)	6	0.703	0.618 - 0.788	0.611 - 0.833	**0.0017***
Touch for Health	4	0.761	0.637 - 0.886	0.706 - 0.875	**0.0068***
BodyTalk	4	0.690	0.503 - 0.876	0.563 - 0.846	**0.0479***
Health Kinesiology	4	0.555	0.408 - 0.702	0.429 - 0.650	0.3196
Contact Reflex Analysis	3	0.666	0.565 - 0.766	0.625 - 0.706	**0.0193***
Psych-K	3	0.578	0.182 - 0.974	0.400 - 0.708	0.4873
Others†	13	0.615	0.555 - 0.674	0.400 - 0.714	**0.0013***

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; * signifance reached;

** Chance here refers to the hypothetical situation where either outcome (strong or weak) was equally likely: 50-50.

† Other kMMT Technique Systems (# Practitioners) included: Clinical Kinesiology (2), Kinesionics (2), Nutritional Response Testing (2), and 1 Practitioner each of: Be Set Free Fast (BSFF), Belief System Technique, BioKinesiology, Energy Kinesiology, GeoTran Integrations, Lifeworks, Nambudripad's Allergy Elimination Techniques (NAET), Neural Organization Technique (NOT), Sacro Occiptial Technique (SOT), Soft Tissue Orthopedics (STO), Thought Field Therapy (TFT), Wellness Kinesiology, Wholistic Kinesiology.

APPENDIX TABLE B.2.6 - Table of correlations (and p-values) among kMMT accuracy and the difference in Test Patient confidence ratings (r).

		1.	2.	3.
1.	The Change in TP Confindence in kMMT in General: Post – Pre	1.0000		
2.	The Change in TP Confindence in Practitioner: Post – Pre	0.3344	1.0000	
	p-value:	*0.0231*		
3.	The Change in TP Confindence in Practitioner's kMMT Ability: Post – Pre	0.2982	0.8681	1.0000
	p-values:	*0.0441*	*0.0000*	
4.	kMMT Accuracy	0.1248	0.0564	0.0887
	p-values:	*0.4085*	*0.7095*	*0.5576*

kMMT, kinesiology-style Manual Muscle Testing;

= Correlation (r) reached significance ($p<0.05$); MMT Accuracy - no correlations (r) reached

APPENDIX TABLE B.2.7 - Table of correlations (and p-values) among kMMT accuracy and the difference in Practitioner confidence ratings (r).

		1.	2.	3.
1.	Change in Practitioner's Confidence in kMMT in General: Post – Pre	1.0000		
2.	Change in Practitioner's Confidence in own kMMT Ability: Post – Pre	0.5040	1.0000	
	p-value:	*0.0004*		
3.	kMMT Accuracy	0.1444	0.0641	1.0000
	p-values:	*0.3384*	*0.6722*	
4.	kMMT Accuracy - Misled Condition	0.0402	0.0629	0.3476
	p-values:	*0.7908*	*0.6780*	*0.0155*

kMMT, kinesiology-style Manual Muscle Testing;

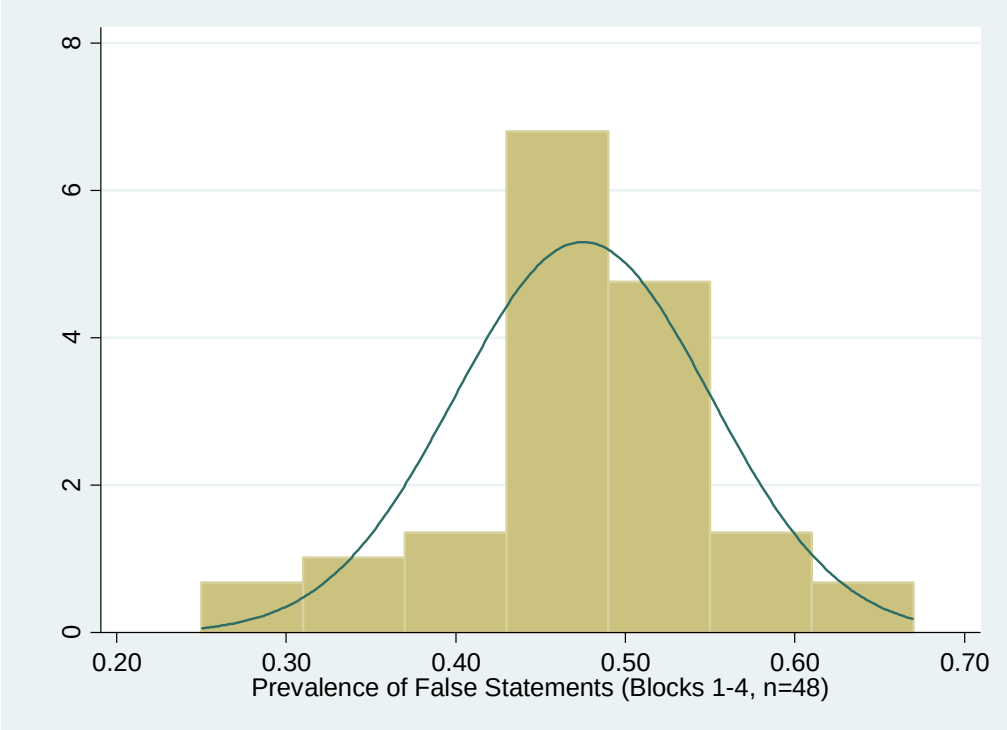
= Correlation (r) reached significance ($p<0.05$); MMT Accuracy - no correlations (r) reached

APPENDIX TABLE B.2.8 - kMMT accuracy for those Pairs in Study 1 whose prevalence of Lies was 0.50.

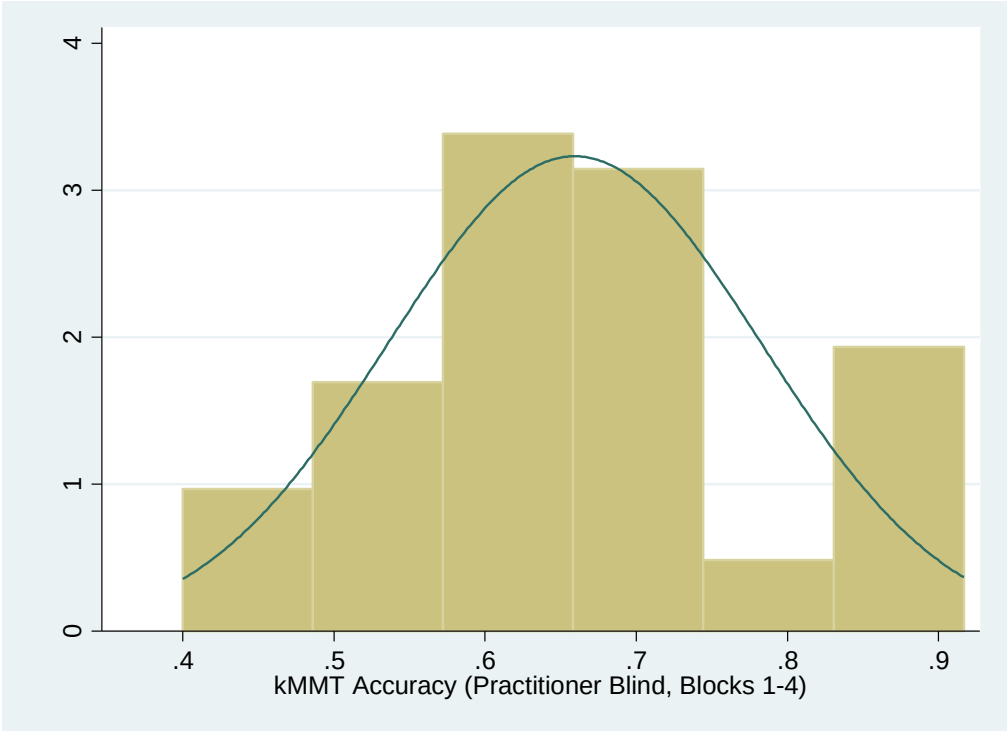
			95% CI	
	n	**Mean**	**Upper**	**Lower**
kMMT Accuracy	9	0.654	0.567	0.741
sensitivity	9	0.649	0.560	0.737
specificity	9	0.693	0.577	0.808
PPV	9	0.754	0.616	0.893
NPV	9	0.554	0.361	0.746

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval.

APPENDIX FIGURE B.2.1 – Histograms showing normal distributions.

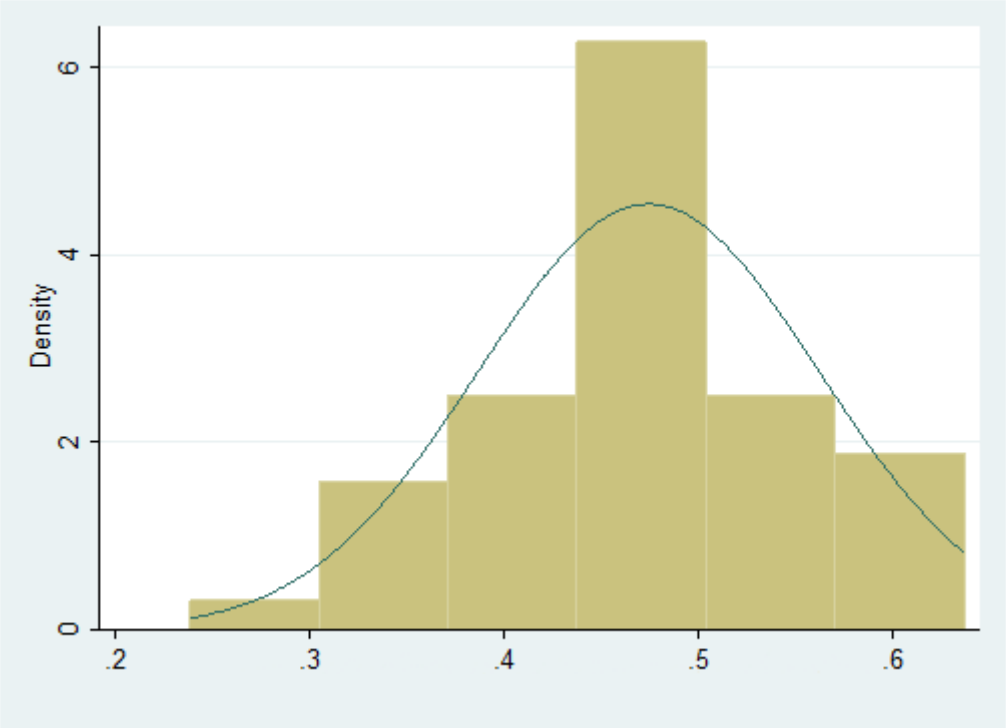


(A)

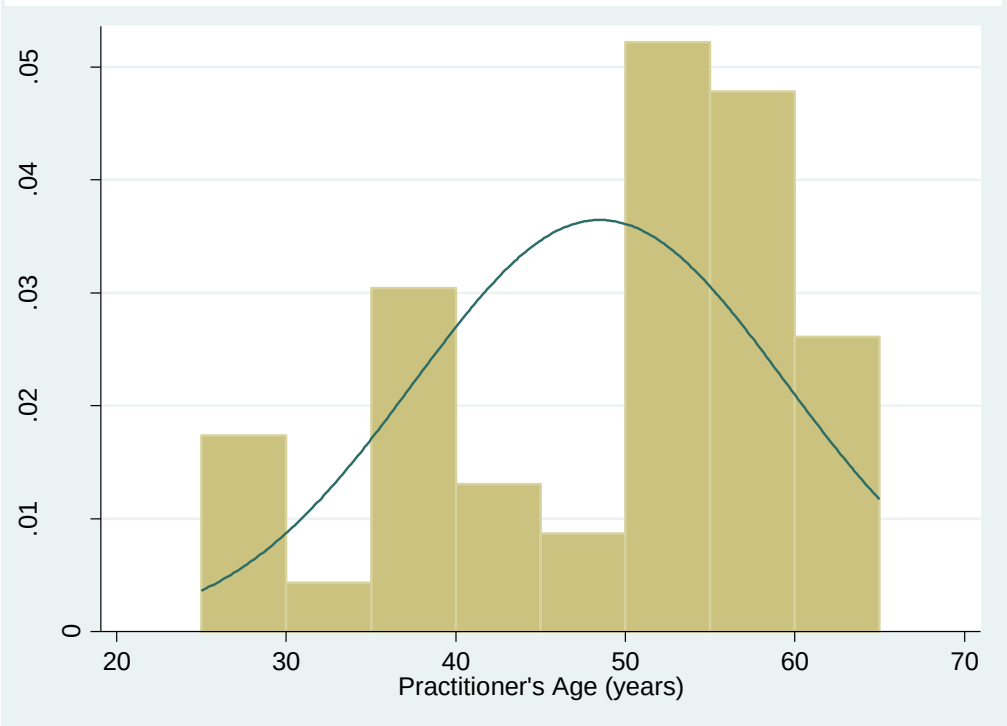


(B)

APPENDIX FIGURE B.2.1 (con't.)

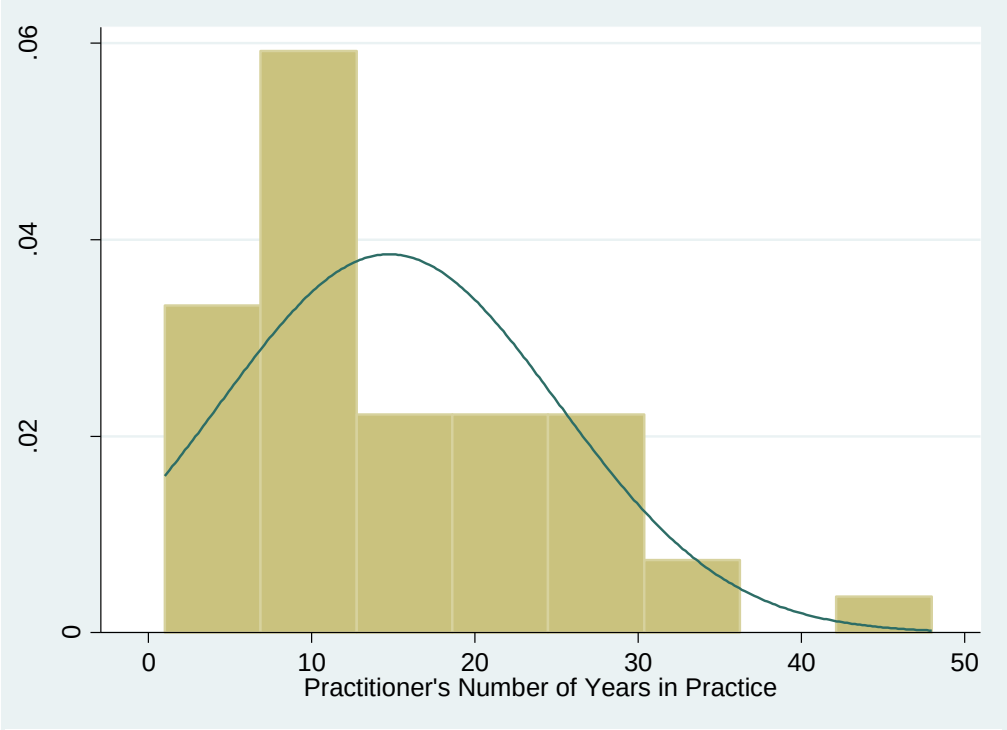


(C)

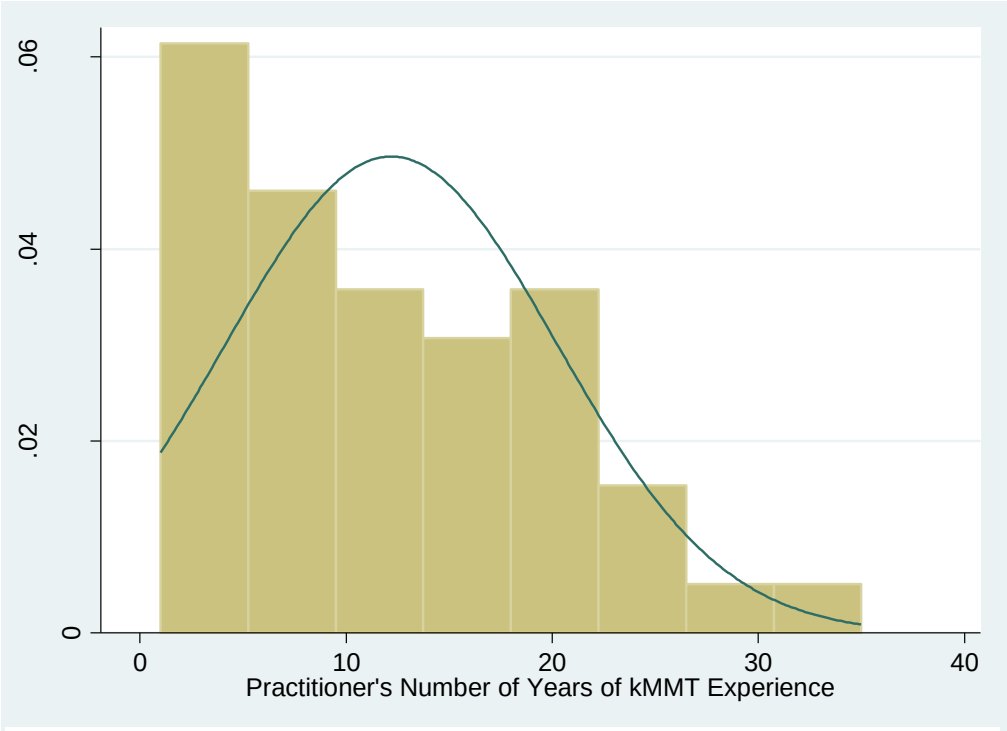


(D)

APPENDIX FIGURE B.2.1 (con't.)

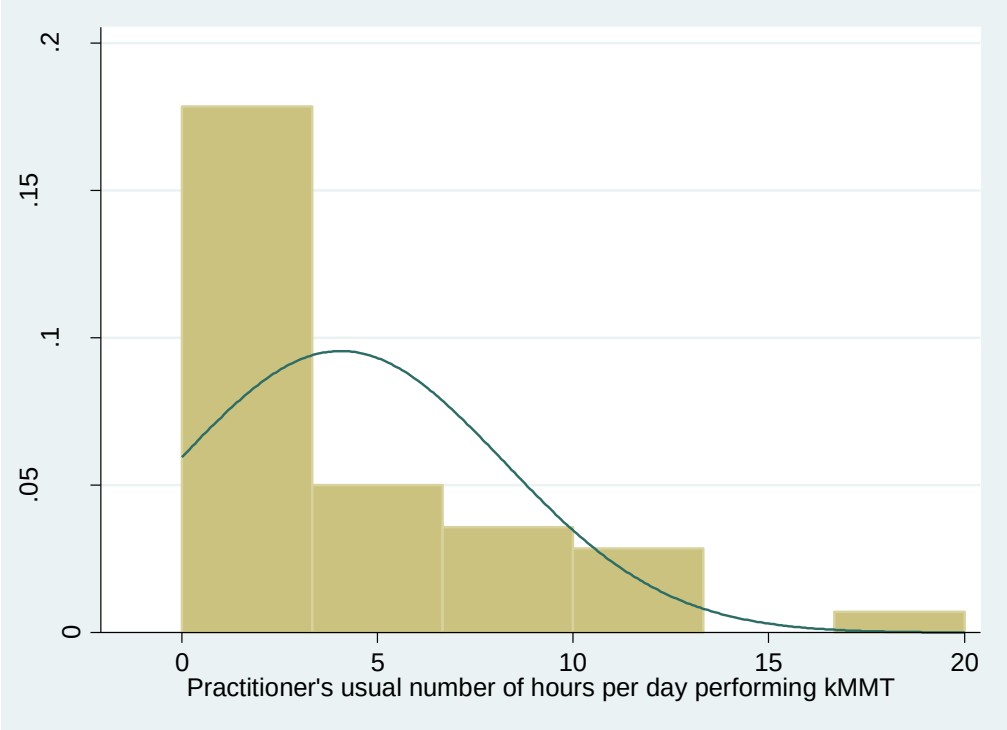


(E)

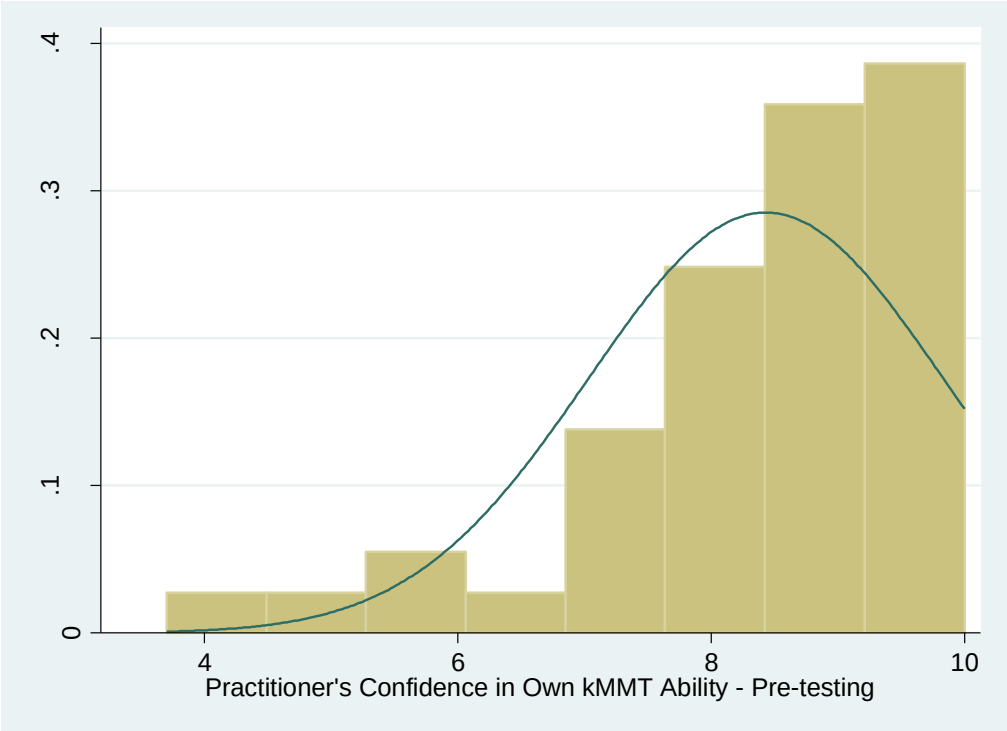


(F)

APPENDIX FIGURE B.2.1 (con't.)



(G)



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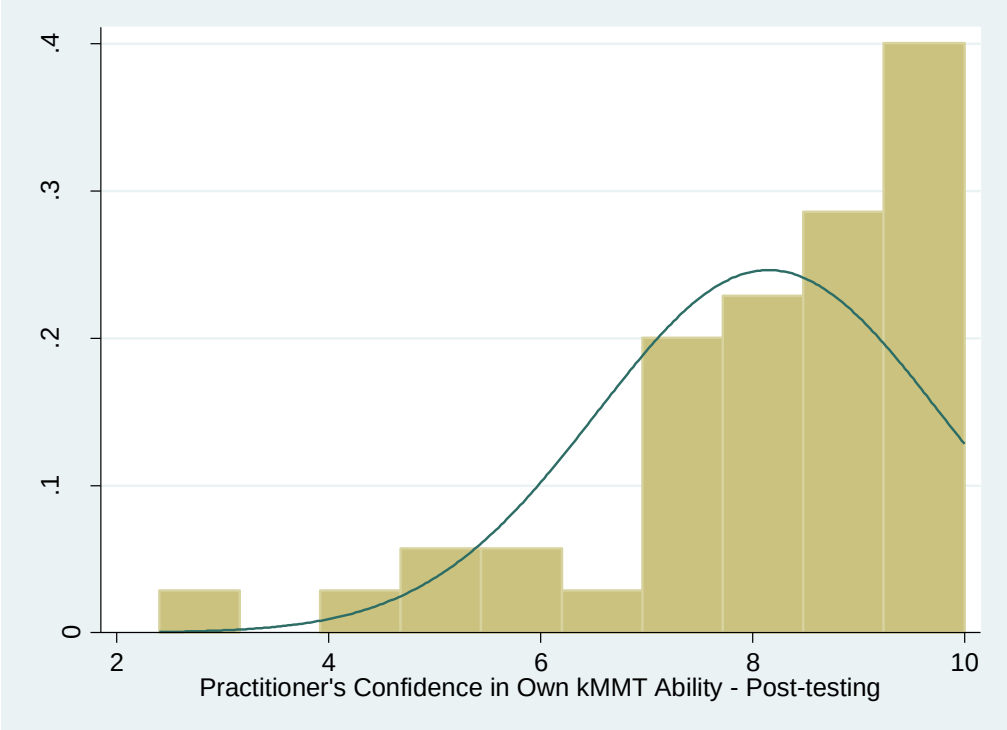
APPENDIX FIGURE B.2.1 (con't.)



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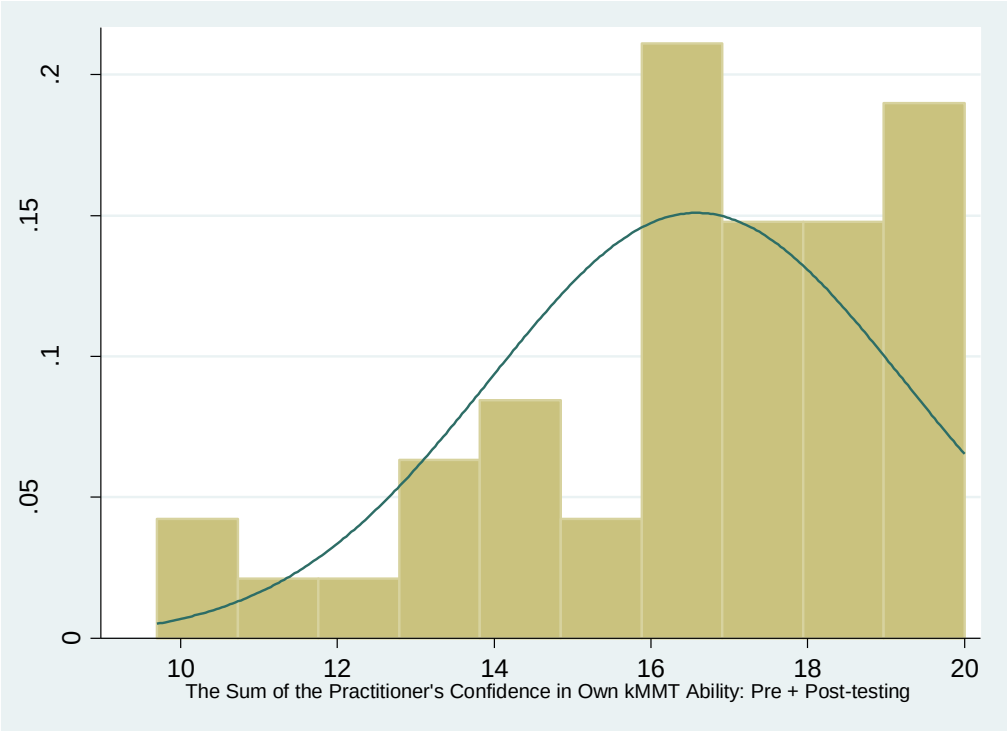

(J)

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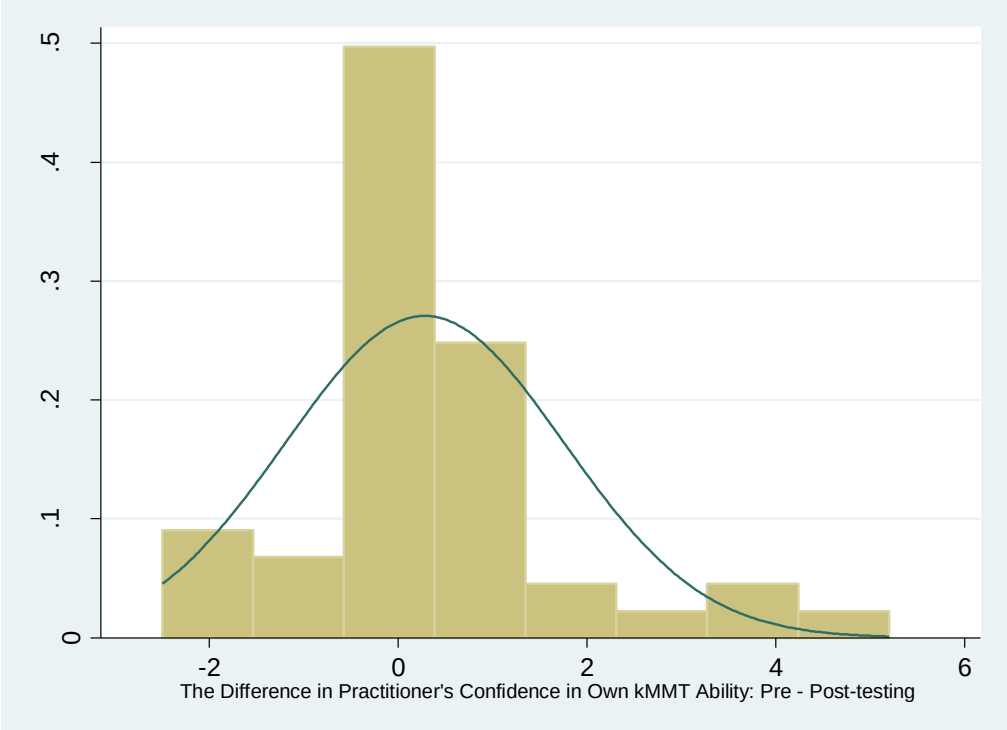

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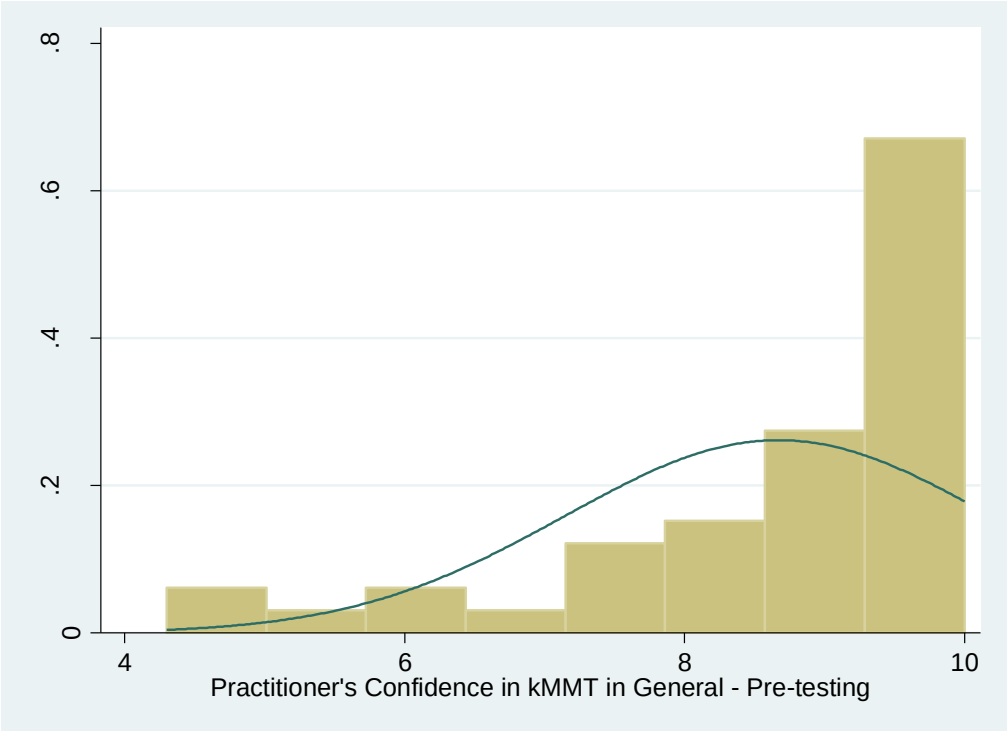

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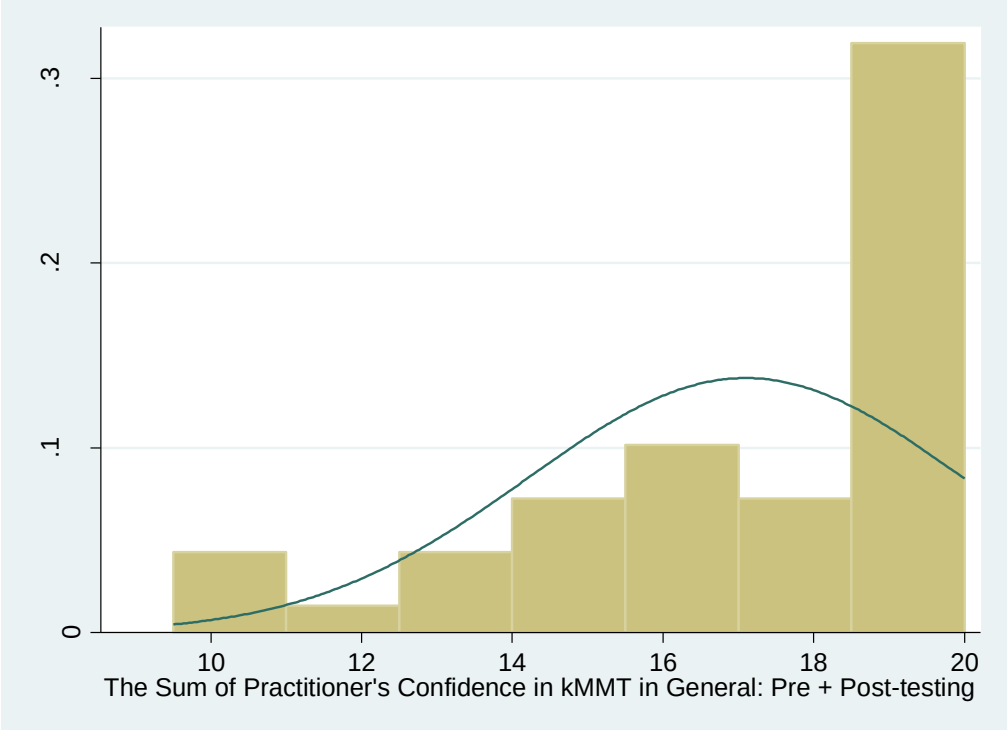

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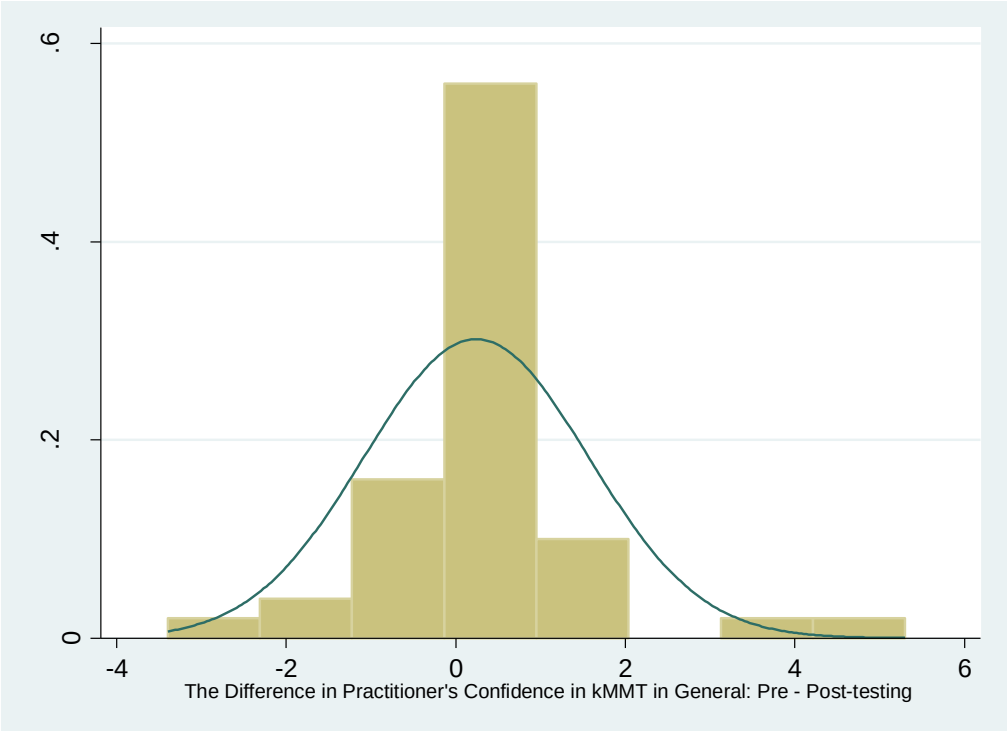

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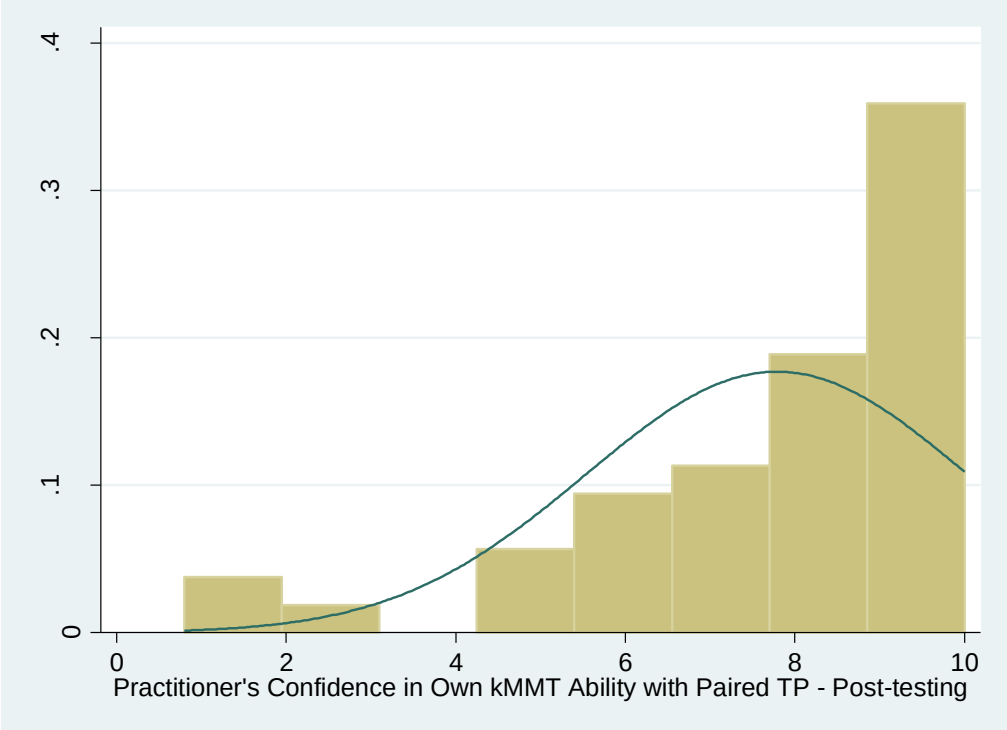

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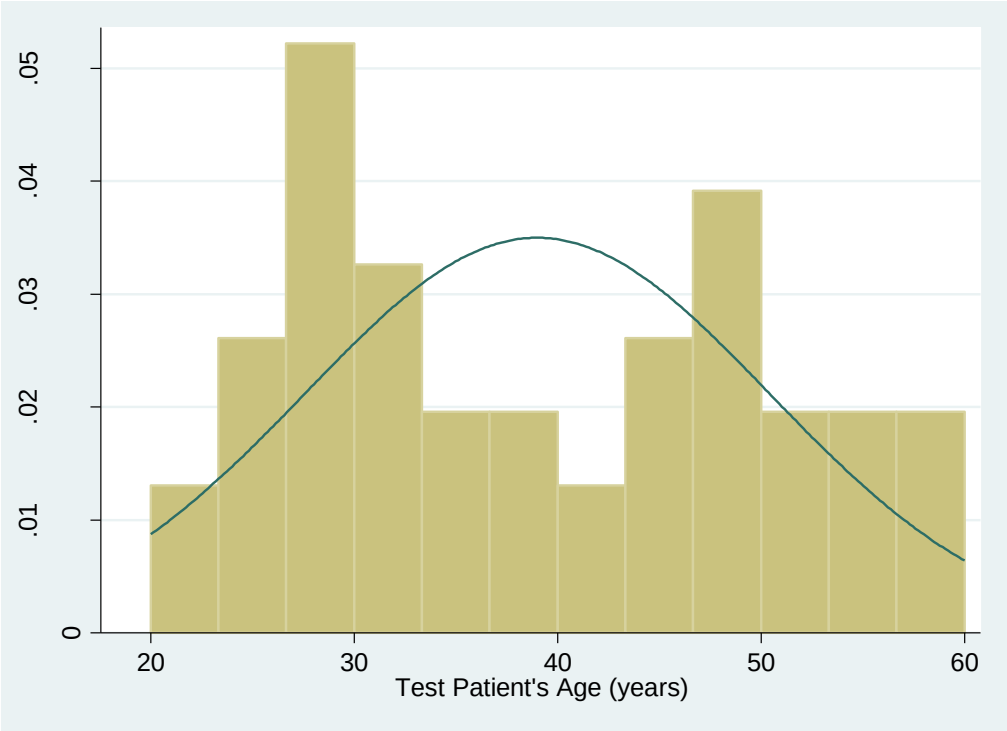

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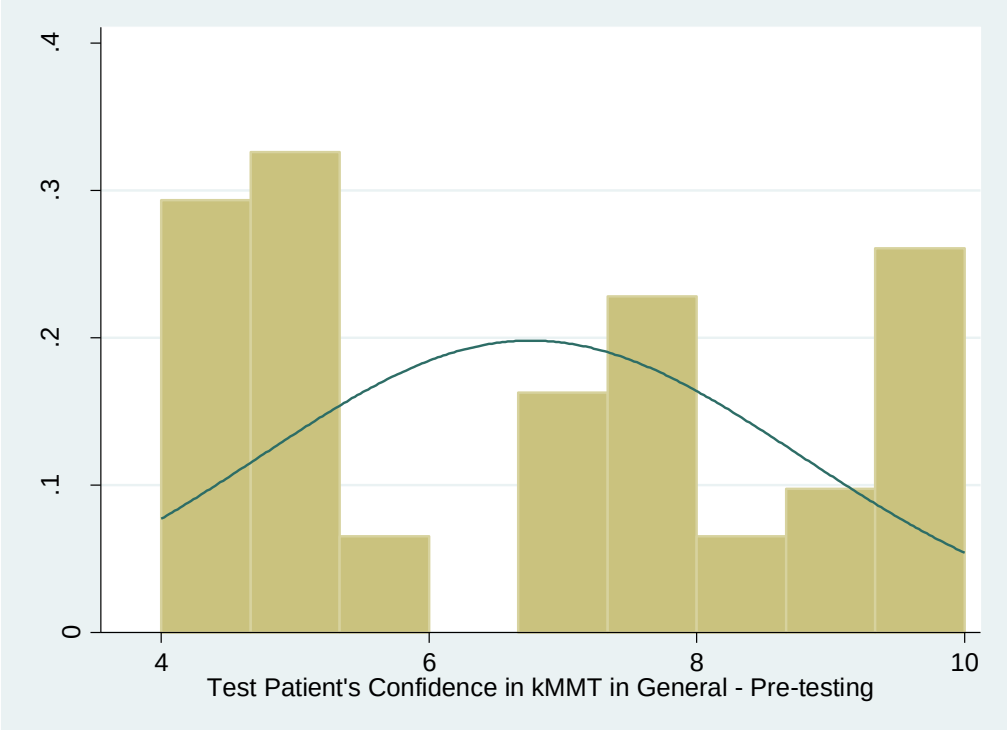
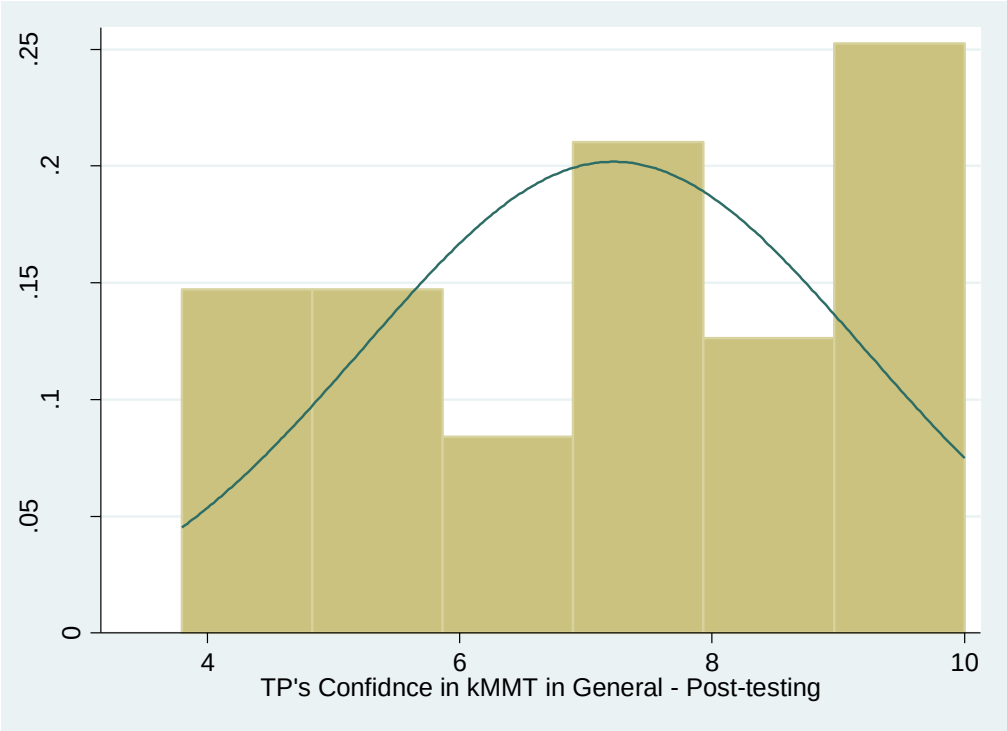


(Q)



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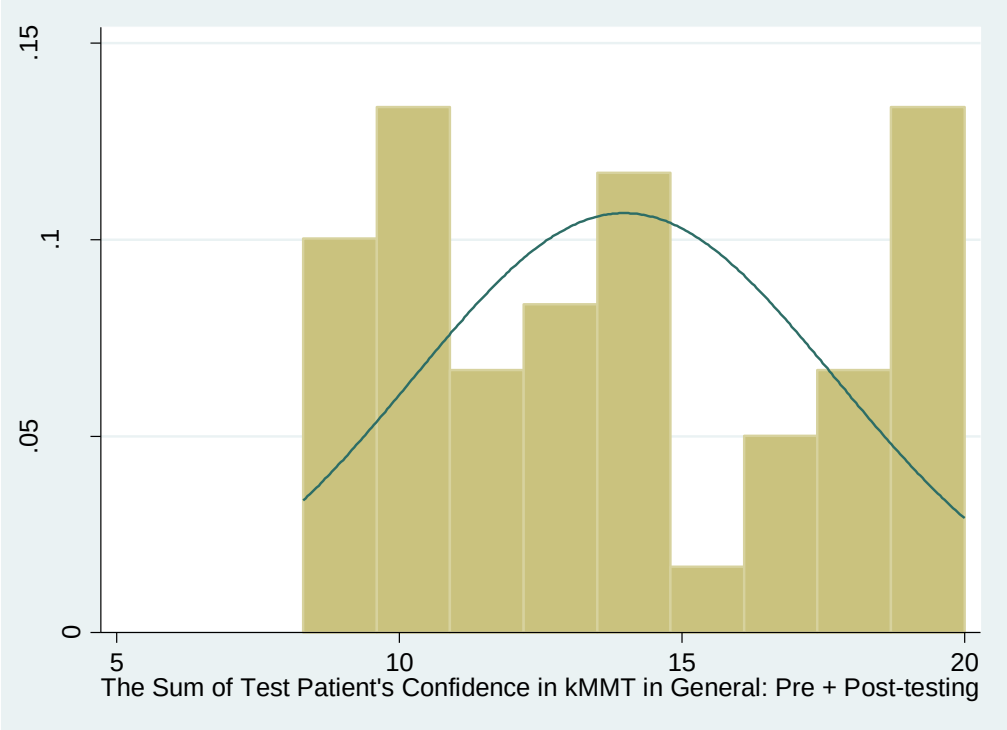
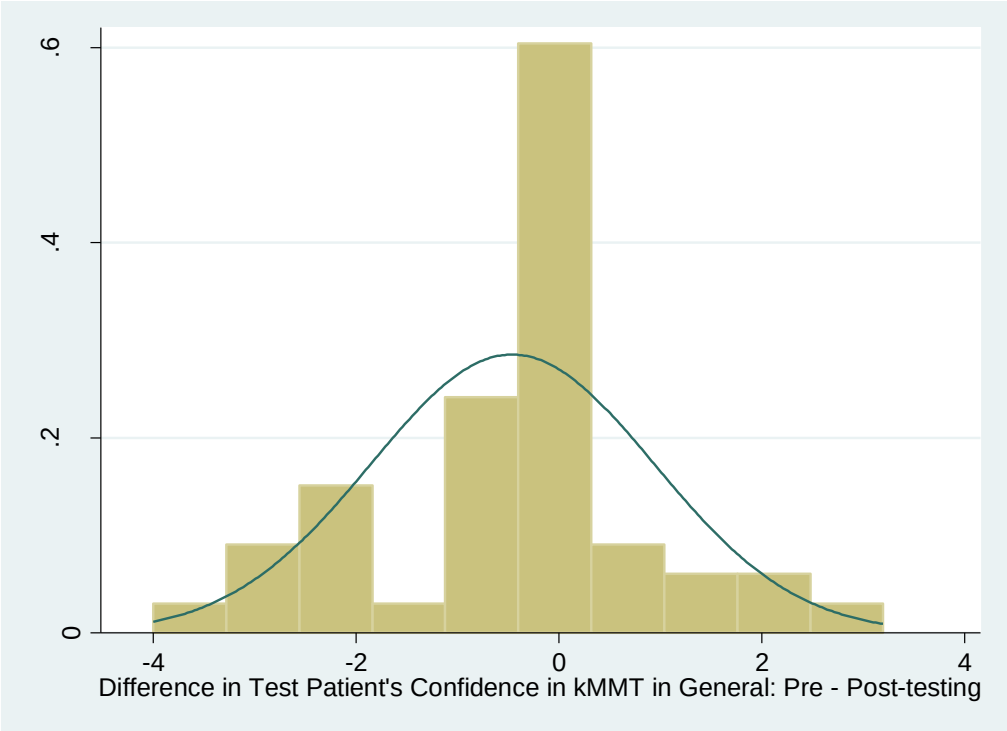
APPENDIX FIGURE B.2.1 (con't.)



(S)



(T)

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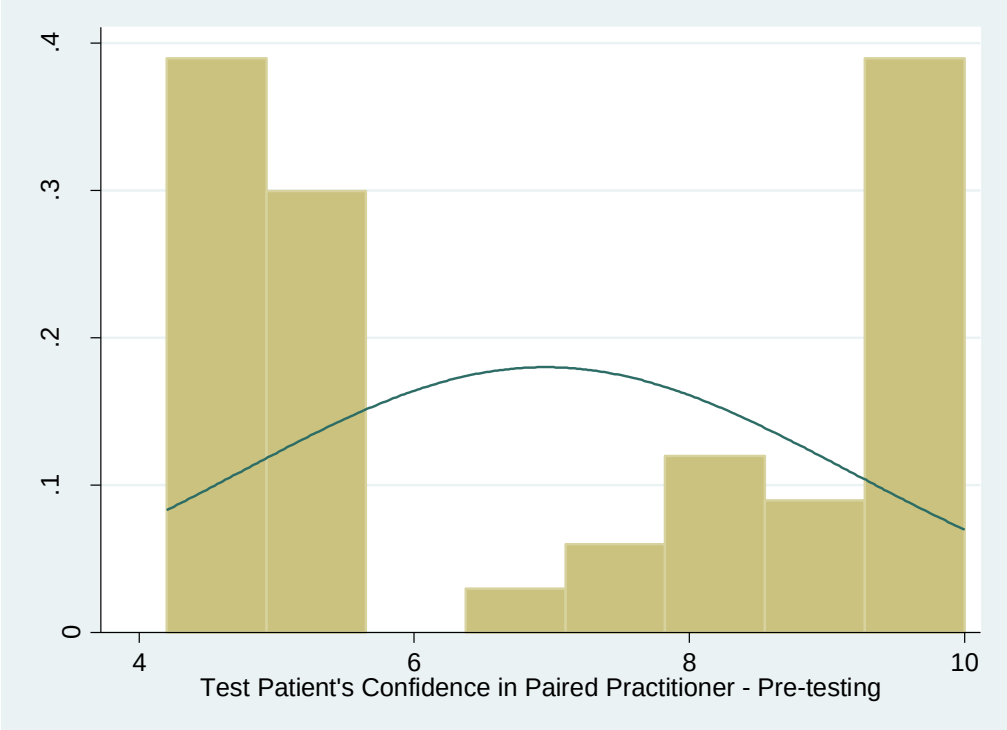
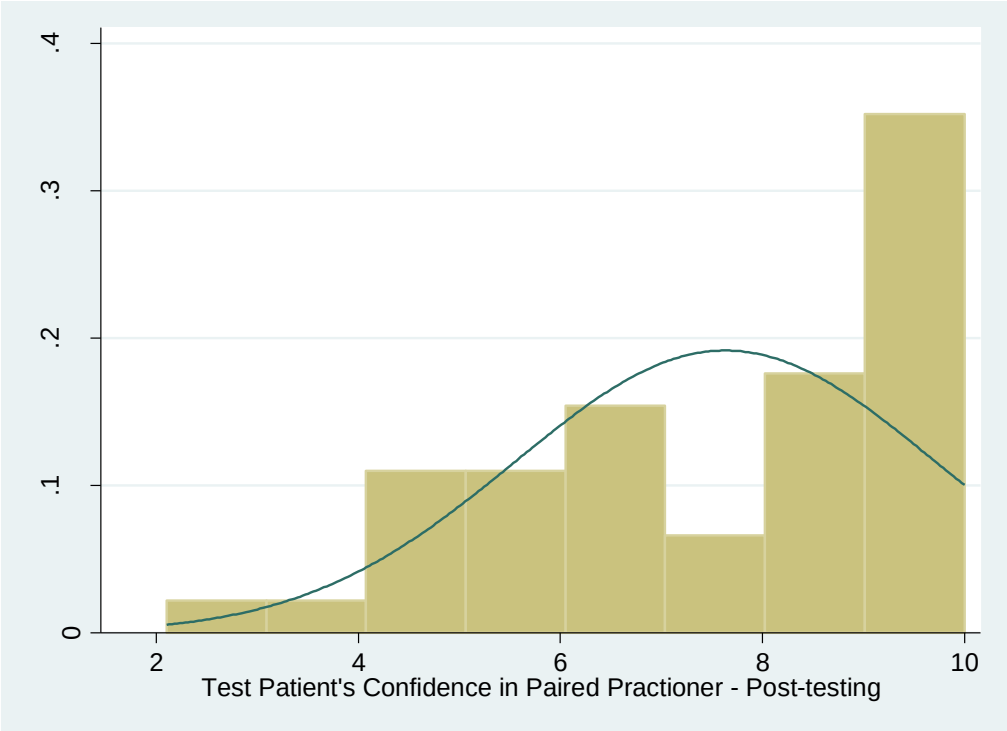


(U)



(V)

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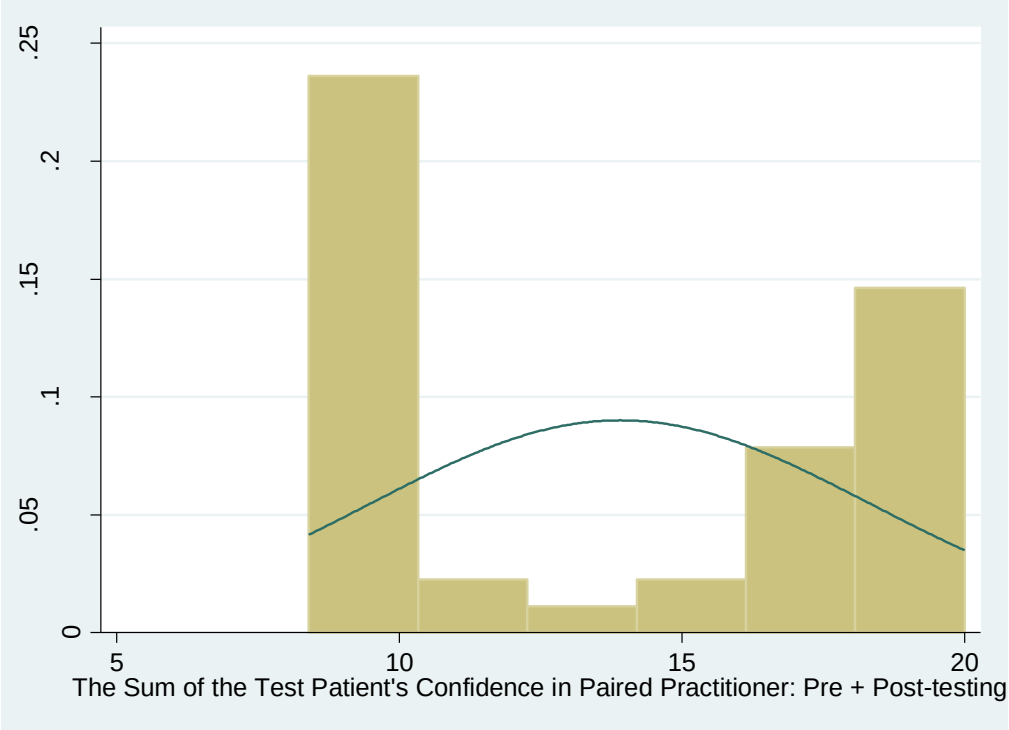

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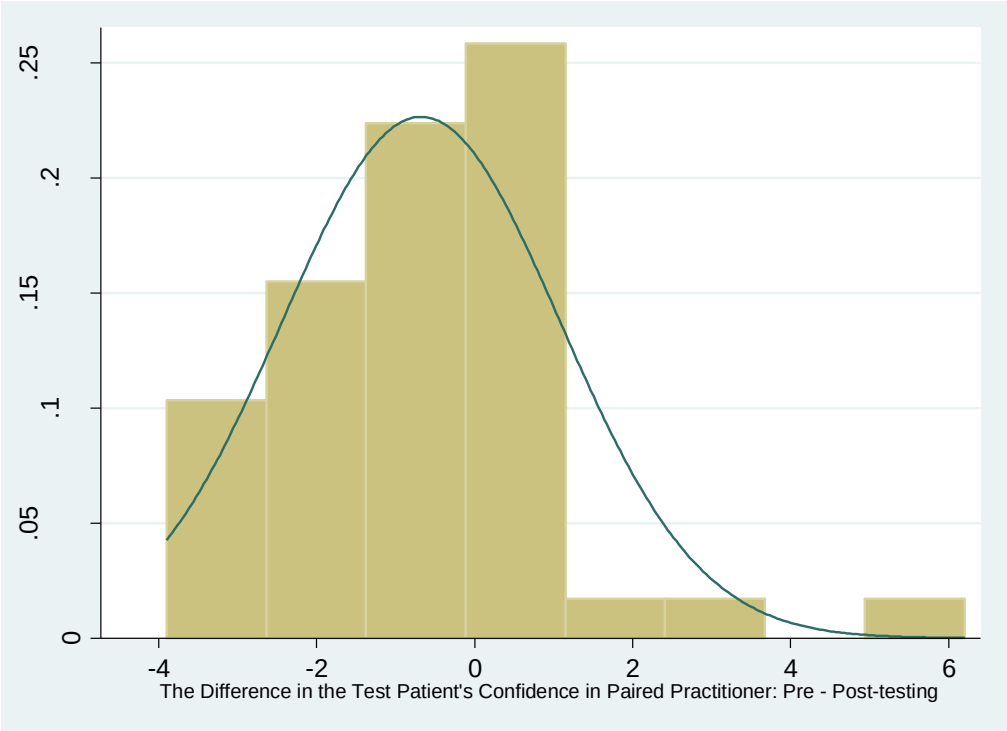

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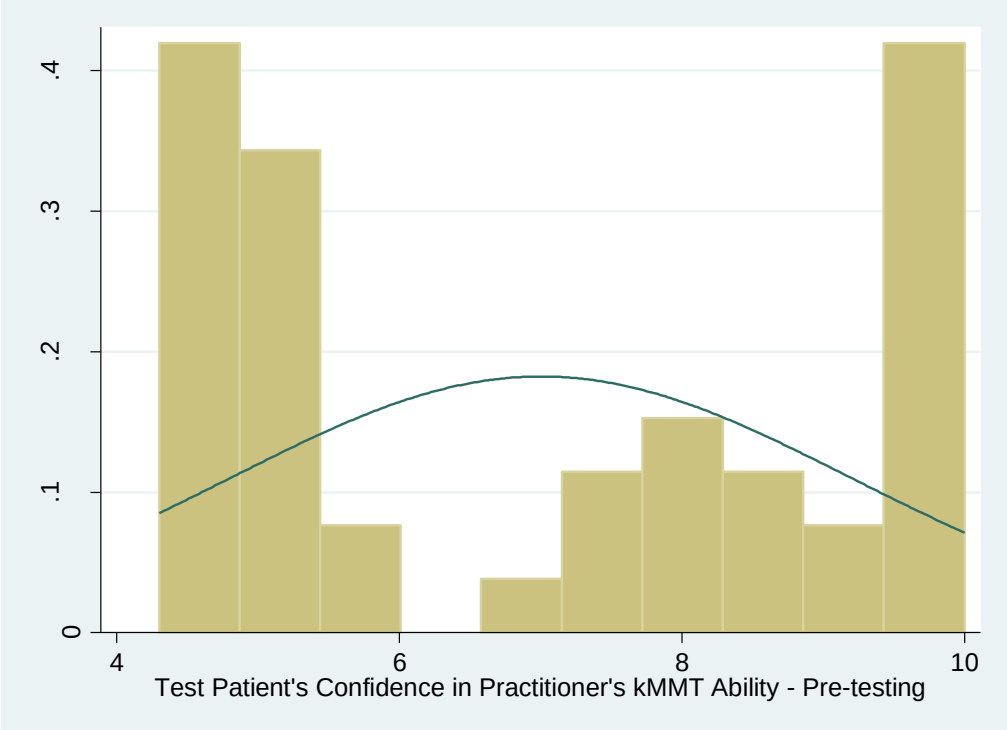

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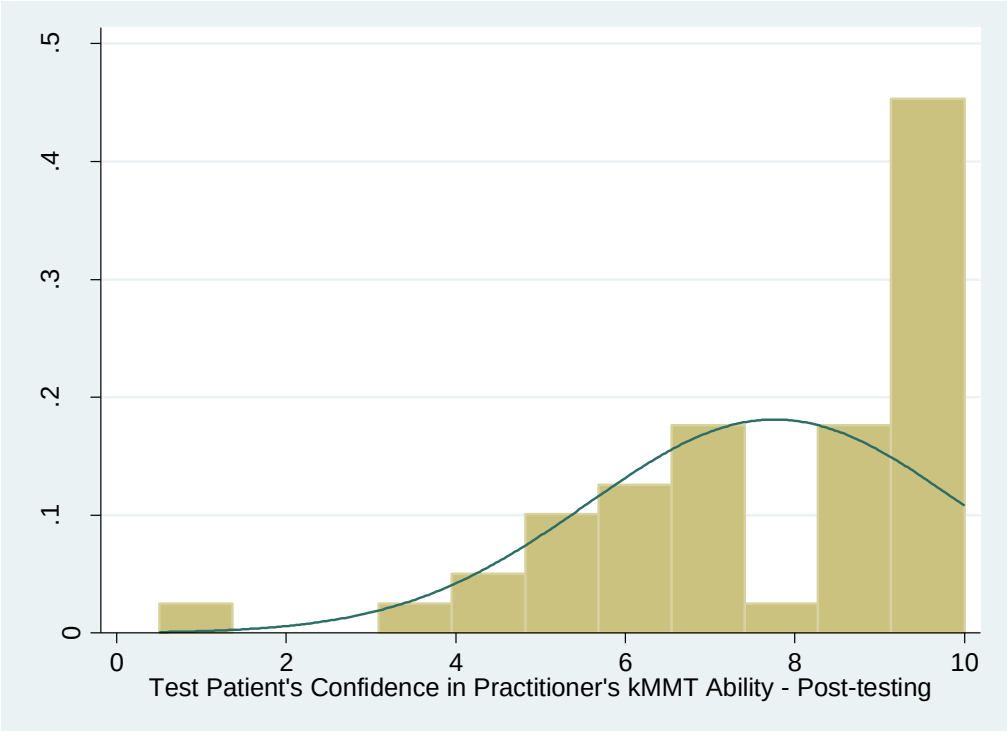

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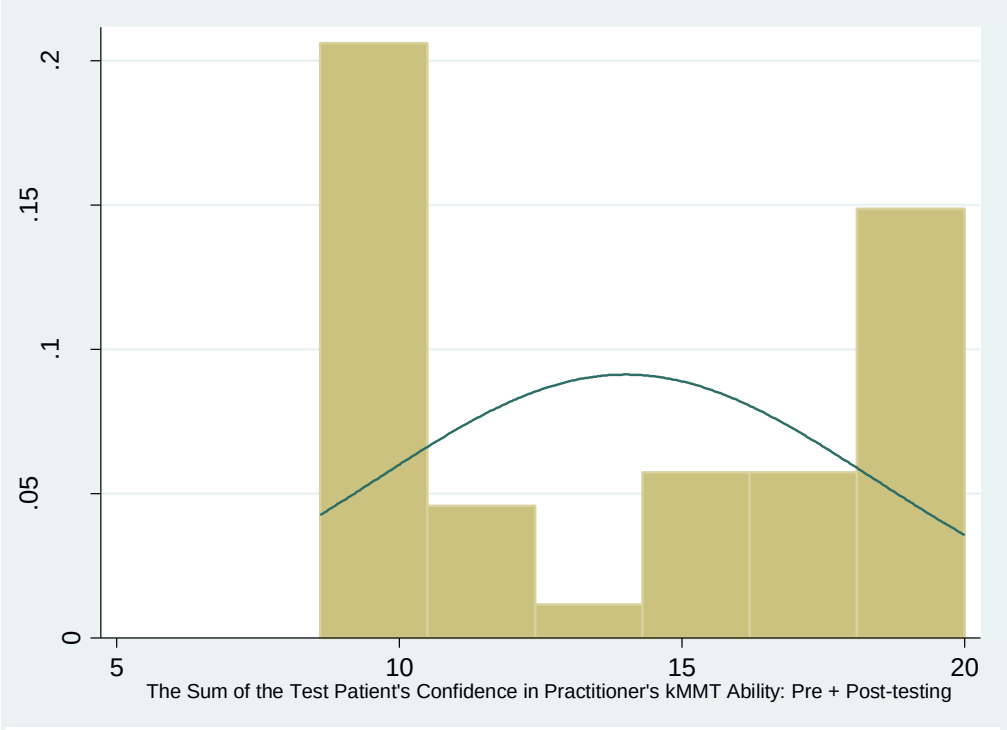

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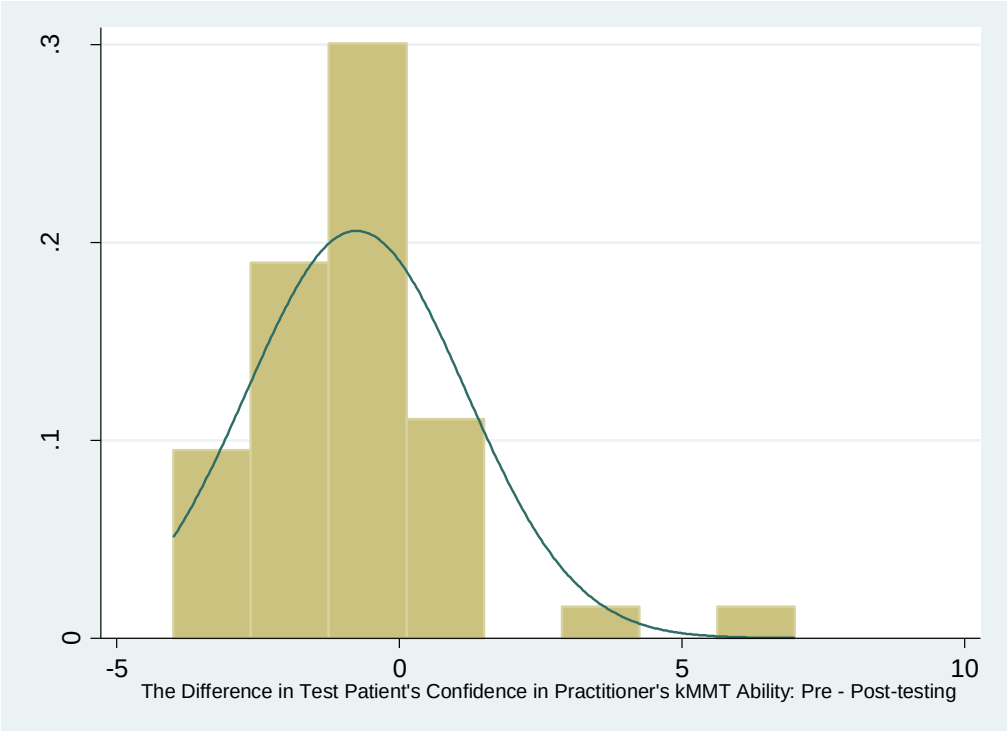
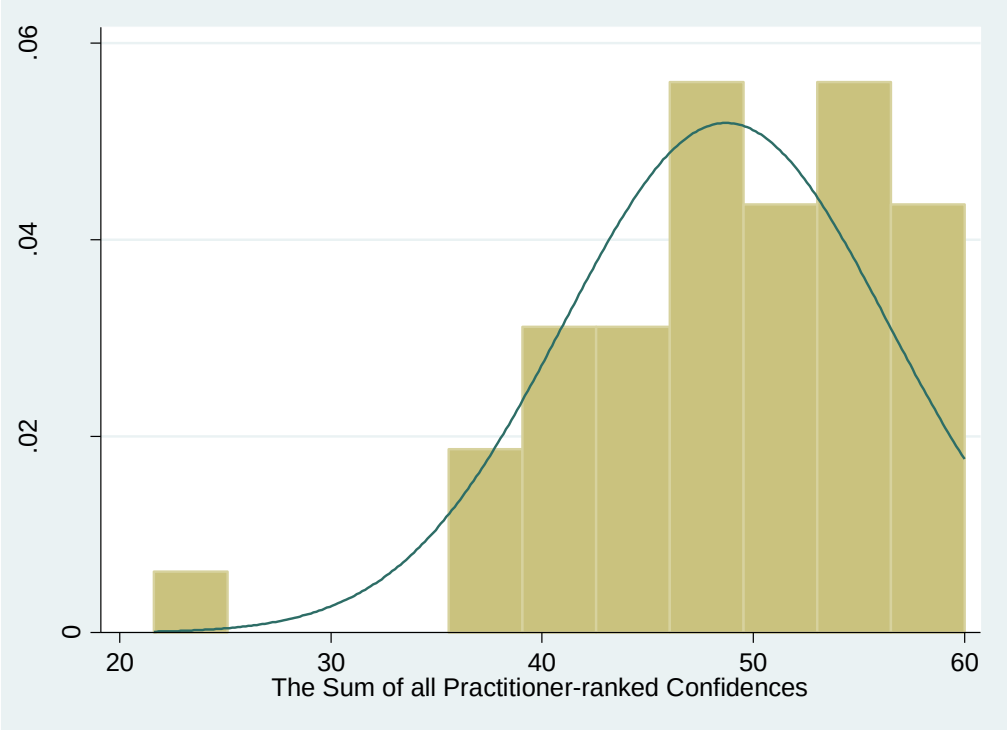


(AB)

APPENDIX FIGURE B.2.1 (con't.)



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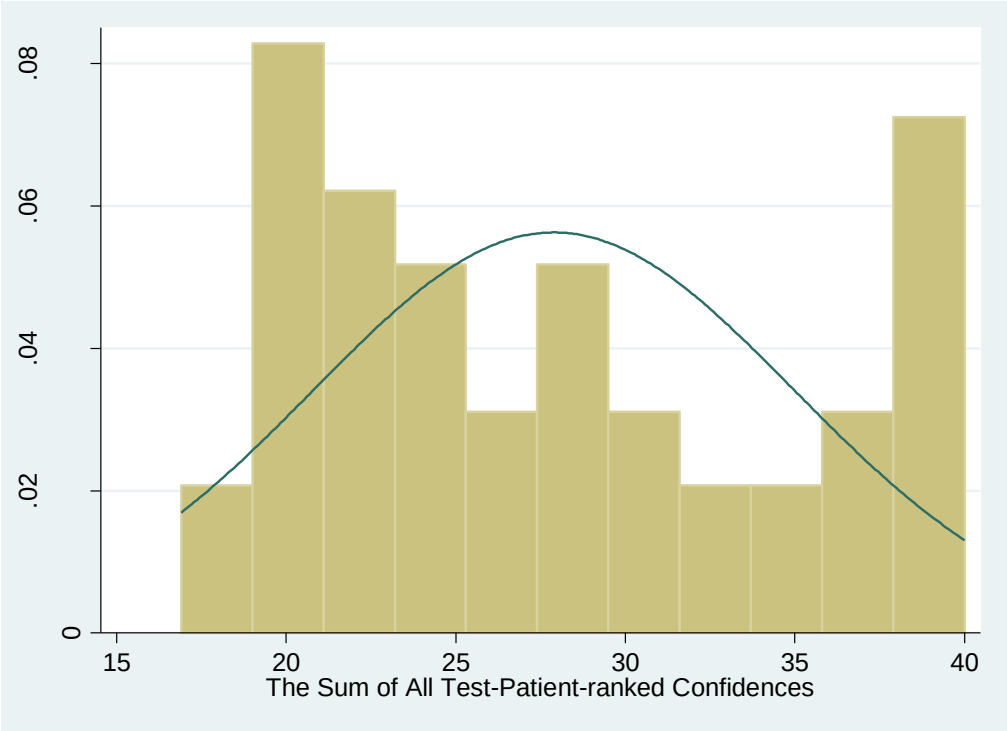
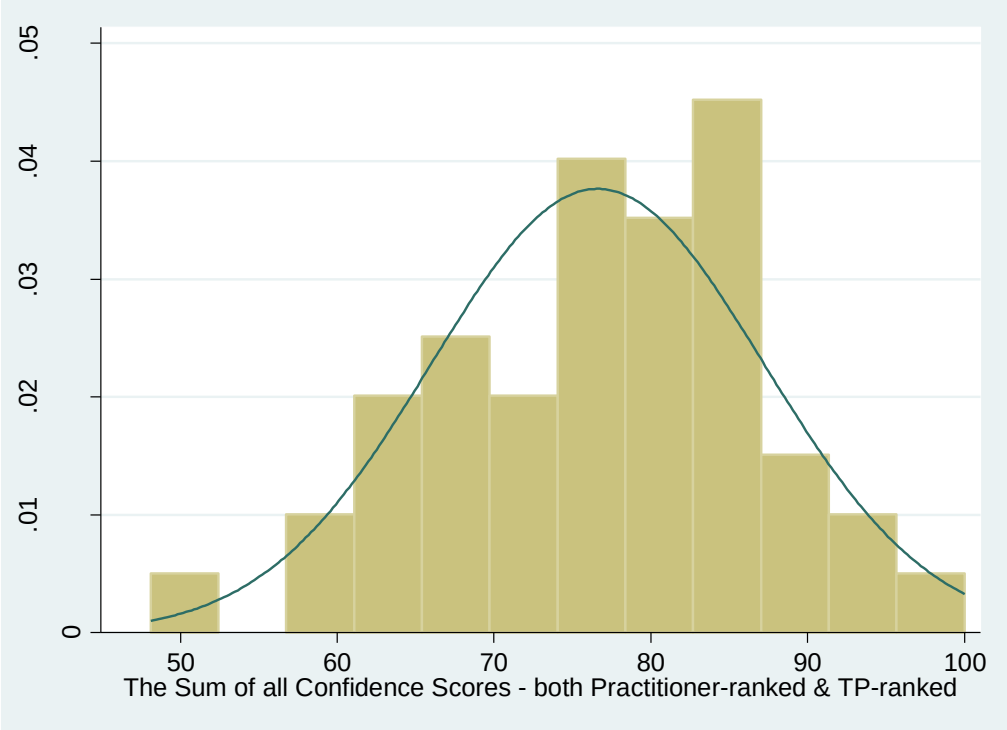


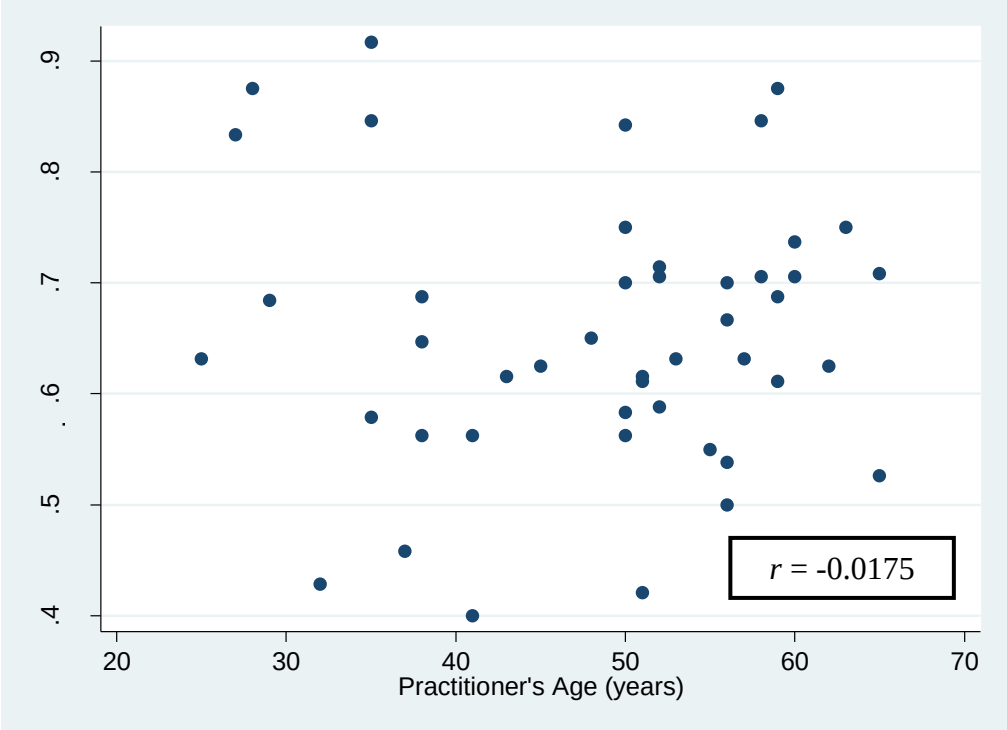
(AD)

APPENDIX FIGURE B.2.1 (con't.)



(AE)

APPENDIX FIGURE B.2.2 – Scatterplots showing correlations and the correlation coefficients (*r*).



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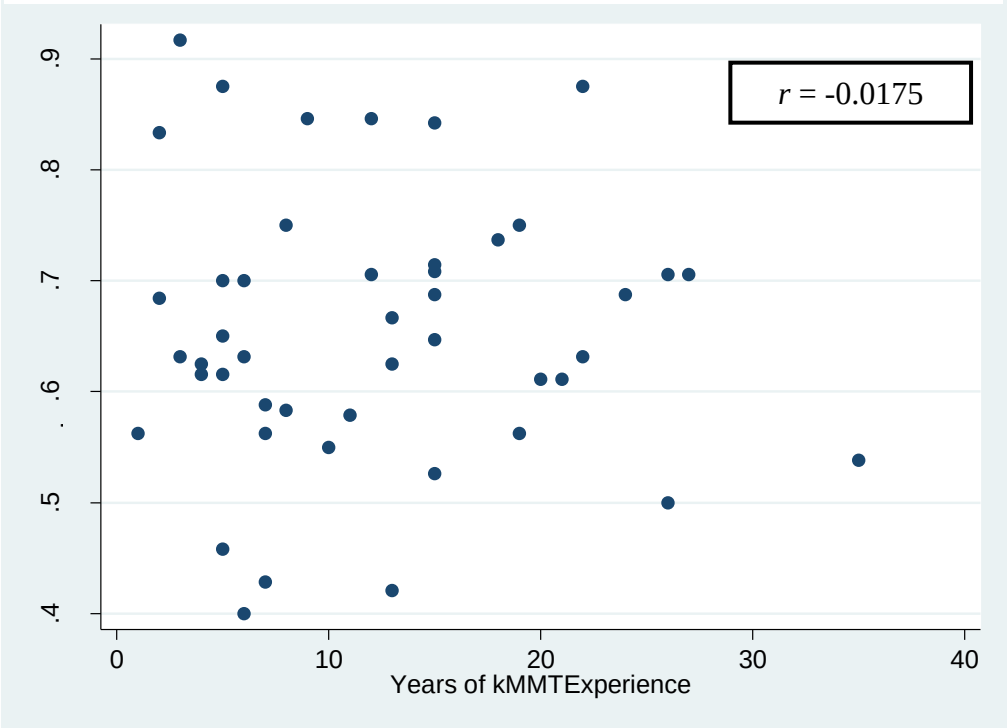
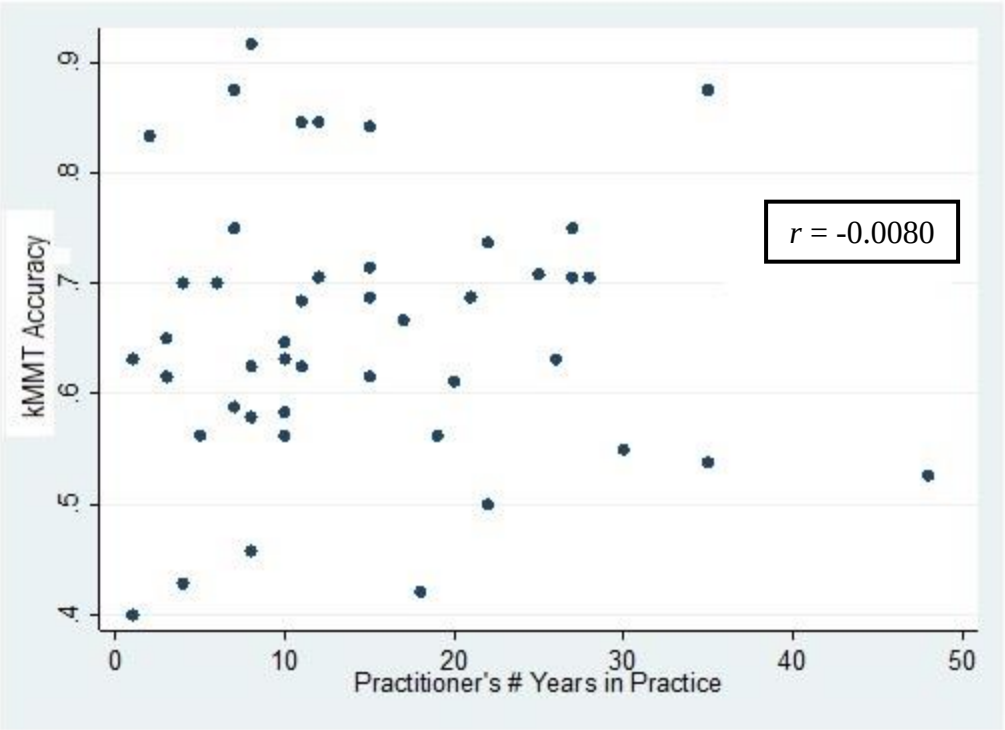
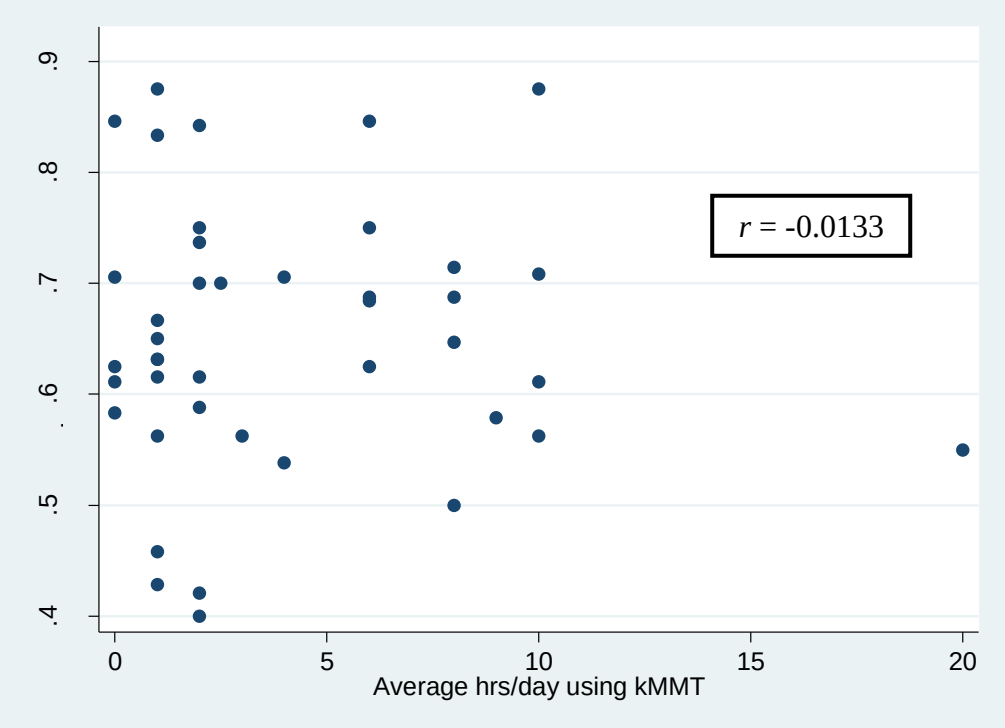


(B)

APPENDIX FIGURE B.2.2 (con't.)

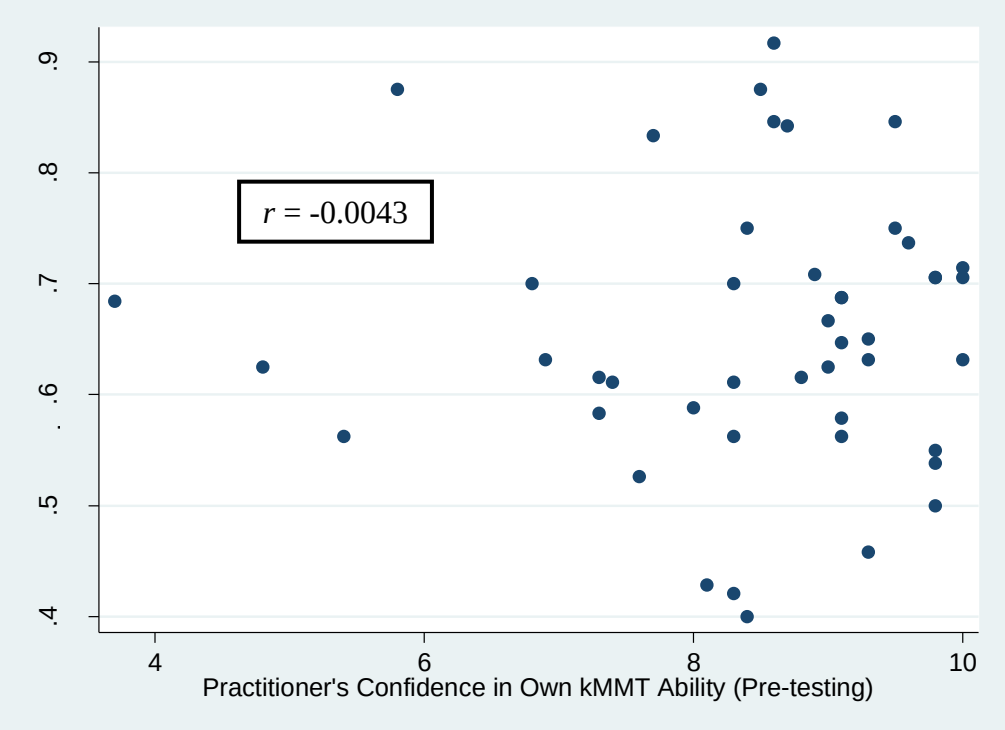


(C)



(D)

APPENDIX FIGURE B.2.2 (con't.)



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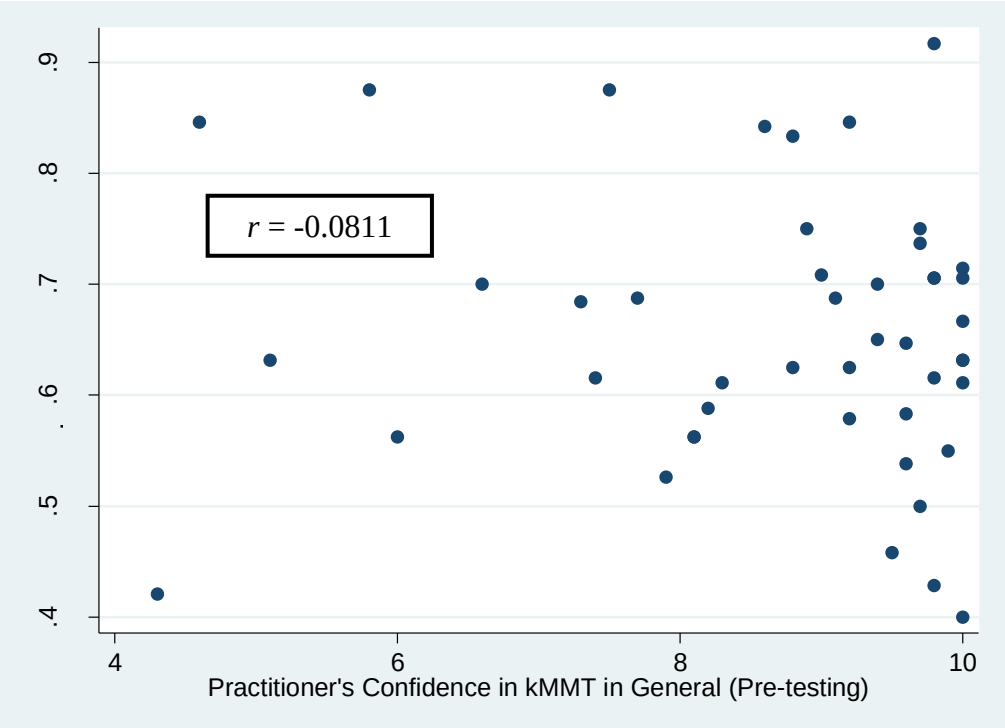
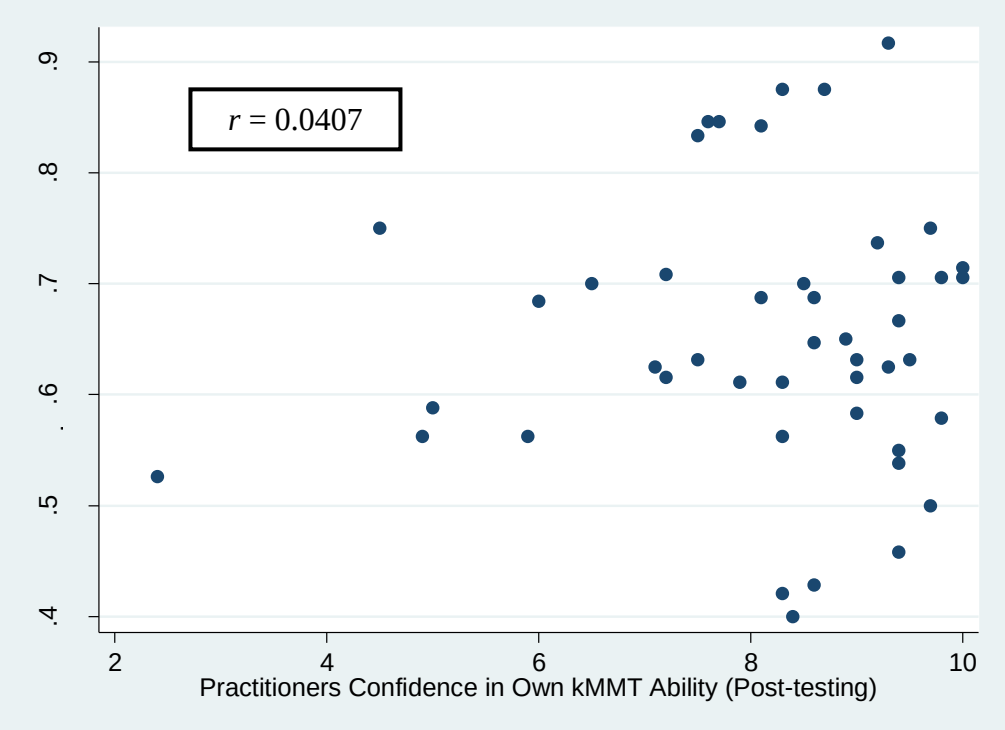


(F)

APPENDIX FIGURE B.2.2 (con't.)



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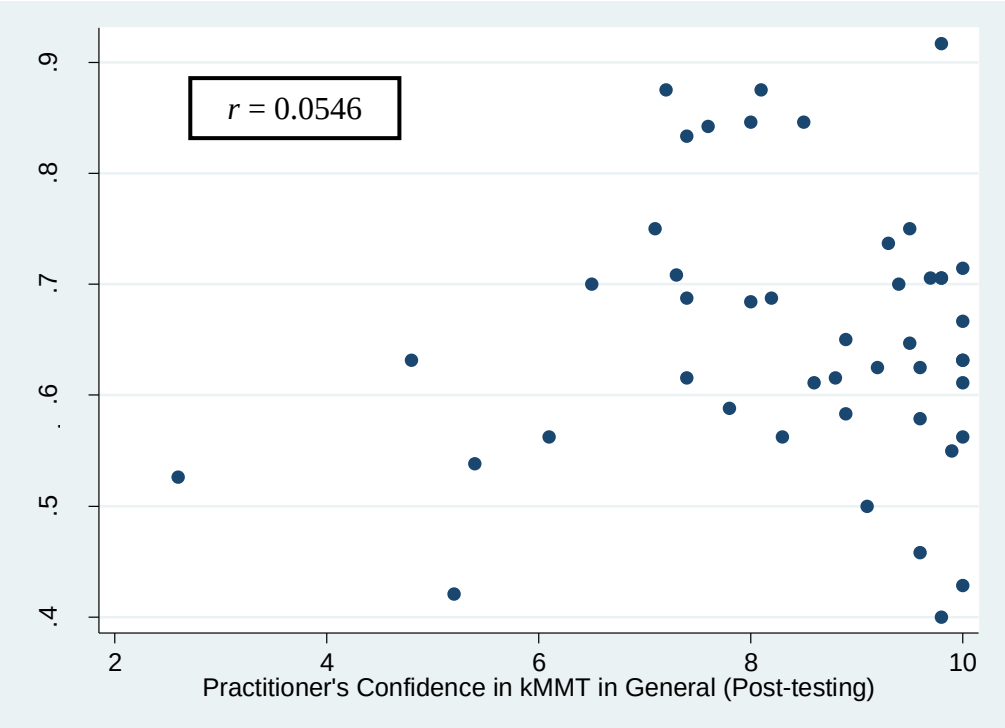
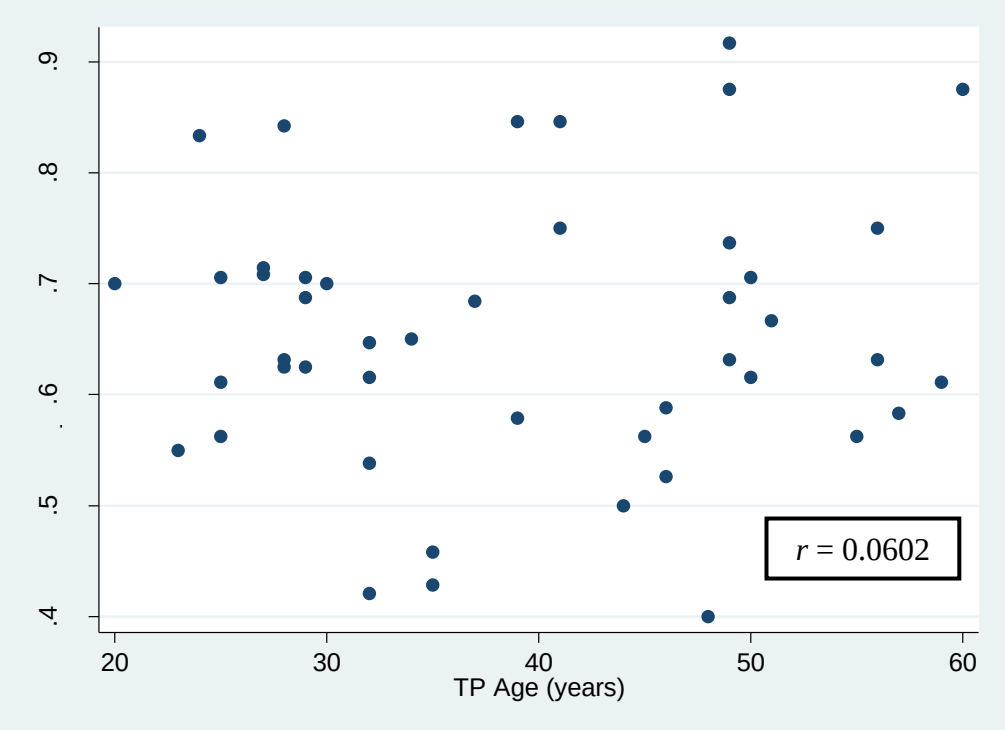
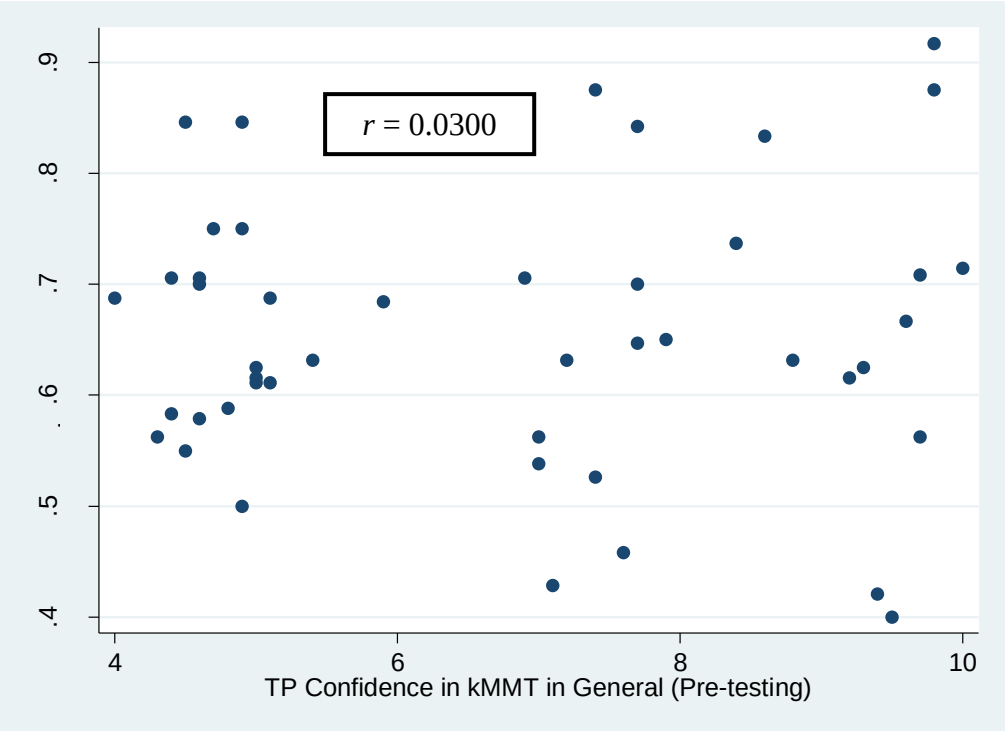


(H)

APPENDIX FIGURE B.2.2 (con't.)



(I)



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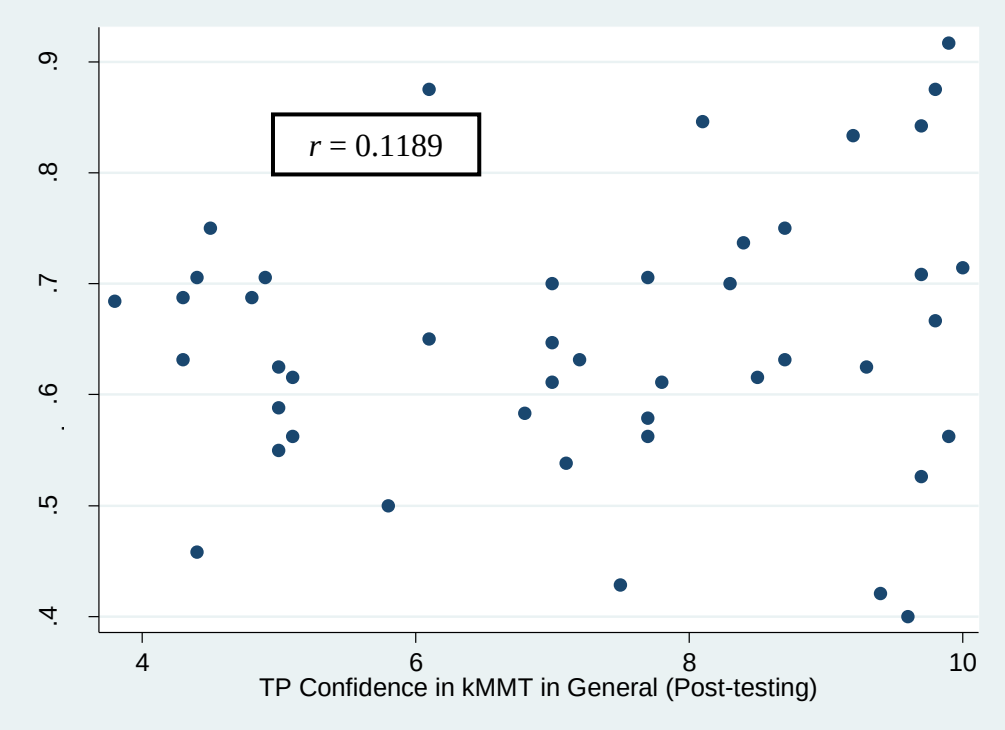
APPENDIX FIGURE B.2.2 (con't.)



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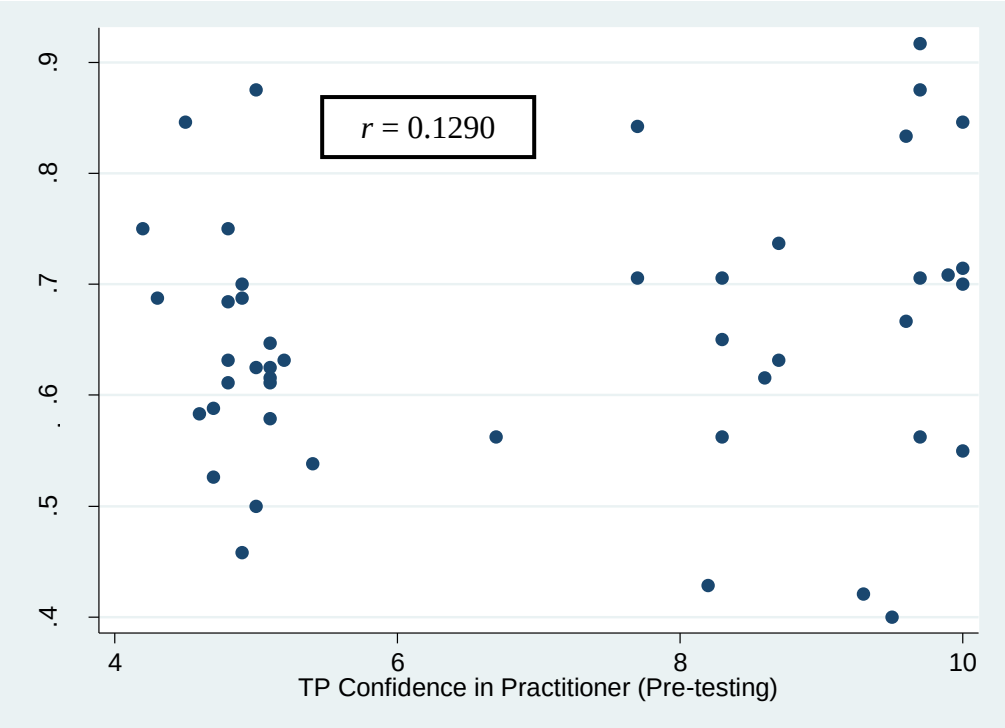
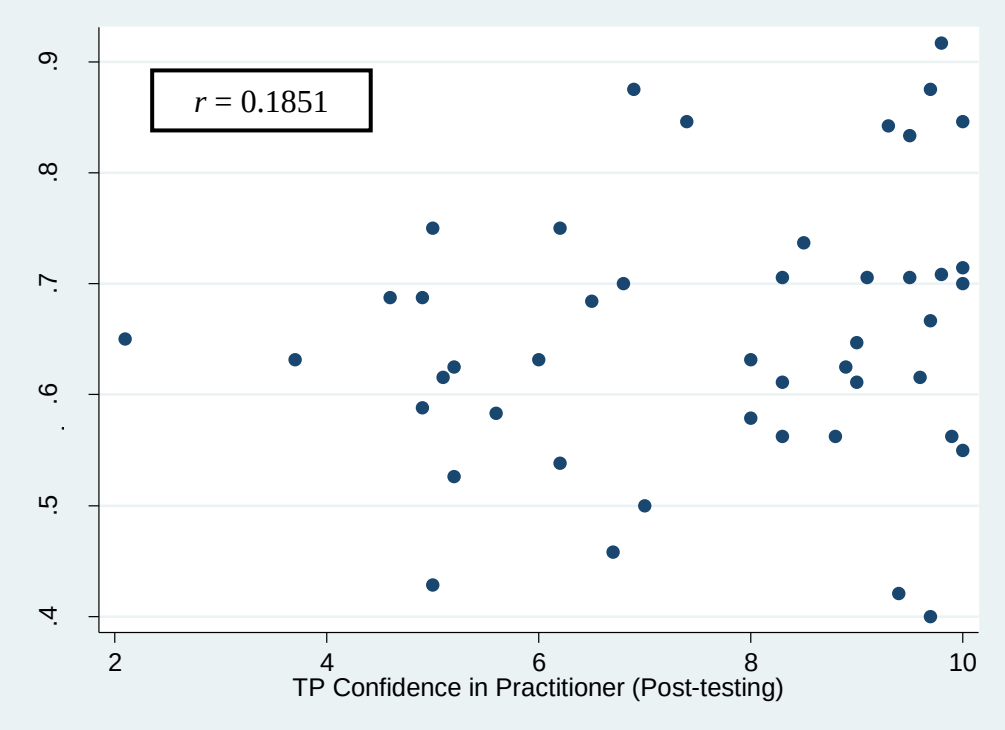
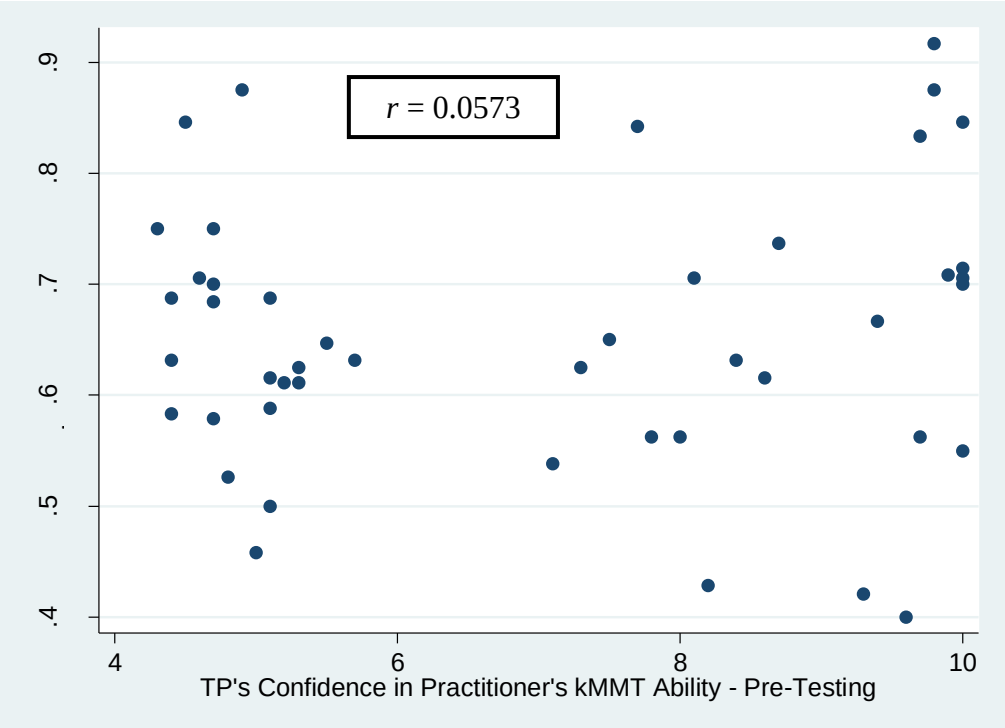


(L)

APPENDIX FIGURE B.2.2 (con't.)

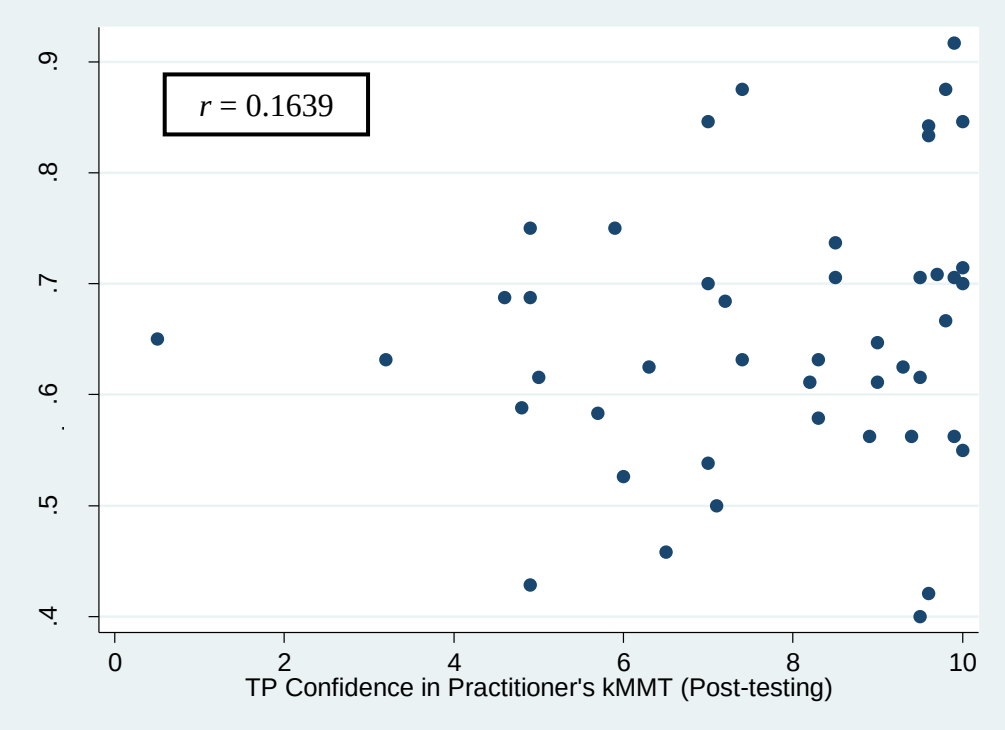


(M)



(N)

APPENDIX FIGURE B.2.2 (con't.)



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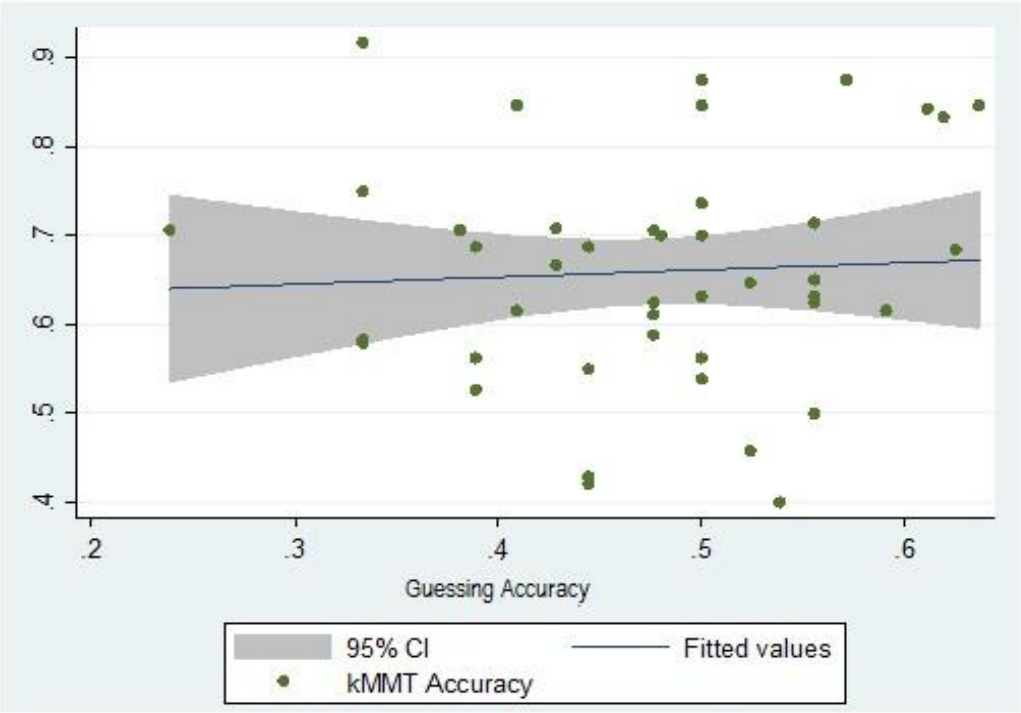
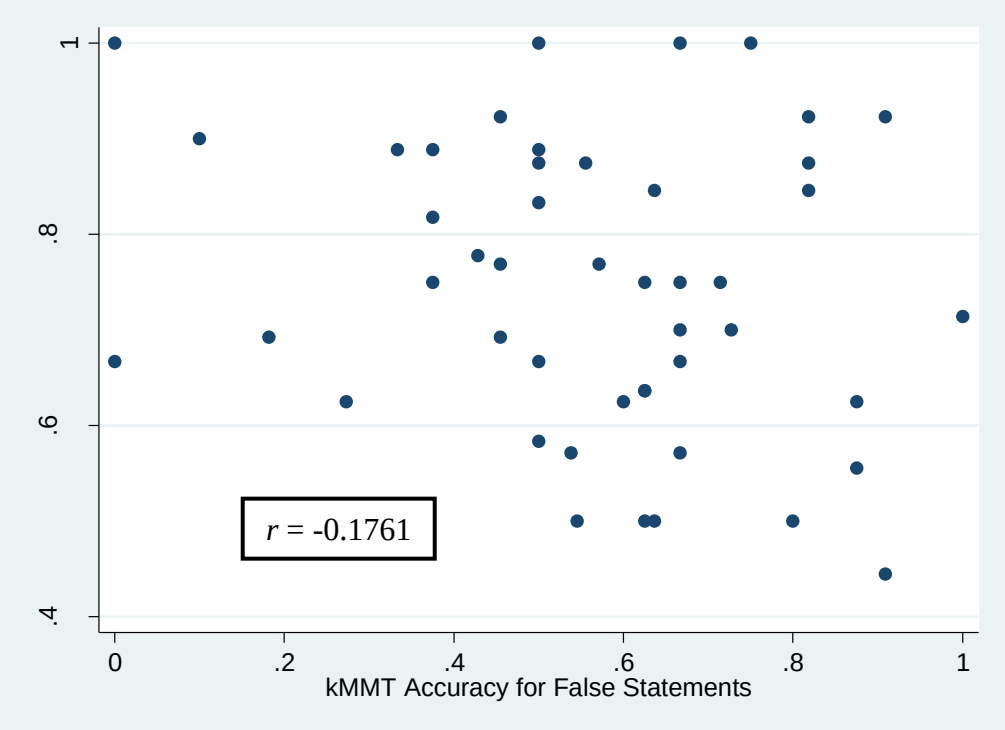


(P) Correlation of kMMT accuracy and Intuition accuracy,
with 95% confidence intervals and fitted values

APPENDIX FIGURE B.2.2 (con't.)



(Q)

CHAPTER 3

APPENDIX TABLE B.3.1 - 2x2 Tables for kMMT for each Pair (n=20). Each Pair performed 40 kMMTs.

Pair 1		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	15	3	18
	Strong (–)	5	17	22
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 2		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	12	6	18
	Strong (–)	8	14	22
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 3		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	9	8	17
	Strong (–)	11	12	23
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 4		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	6	9	15
	Strong (–)	14	11	25
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 5		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	12	10	22
	Strong (–)	8	10	18
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 6		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	5	6	11
	Strong (–)	15	14	29
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 7		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	16	3	19
	Strong (–)	4	17	21
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 8		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	6	5	11
	Strong (–)	14	15	29
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 9		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	12	14	26
	Strong (–)	8	6	14
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 10		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	10	6	16
	Strong (–)	10	14	24
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

APPENDIX TABLE B.3.1 (con't.)

Pair 11		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	13	10	23
	Strong (–)	7	10	17
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 12		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	9	6	15
	Strong (–)	11	14	25
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 13		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	11	6	17
	Strong (–)	9	14	23
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 14		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	7	5	12
	Strong (–)	13	15	28
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 15		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	13	5	18
	Strong (–)	7	15	22
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 16		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	3	2	5
	Strong (–)	17	18	35
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 17		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	10	8	18
	Strong (–)	10	12	22
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 18		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	10	5	15
	Strong (–)	10	15	25
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 19		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	14	2	16
	Strong (–)	6	18	24
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

Pair 20		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	8	7	15
	Strong (–)	12	13	25
	Totals	20	20	40

kMMT, kinesiology-style Manual Muscle Testing.

APPENDIX TABLE B.3.2 - kMMT & Intuition accuracies for all statements, True statements and False statements (for n=20 Pairs).

	ALL STATEMENTS			TRUE vs FALSE STATEMENTS					
				TRUE Statements			FALSE Statements		
	kMMT	Guessing	*p* -value	kMMT	Guessing	*p* -value	kMMT	Guessing	*p* -value
Mean	**0.594**	**0.514**	**0.01***	0.685	0.603	0.06	0.503	0.425	0.07
95% CI	0.541 - 0.647	0.483 - 0.544		0.616 - 0.754	0.555 - 0.650		0.421 - 0.584	0.356 - 0.494	
Minimum	0.425	0.375		0.300	0.450		0.150	0.000	
Maximum	0.825	0.625		0.900	0.800		0.800	0.650	

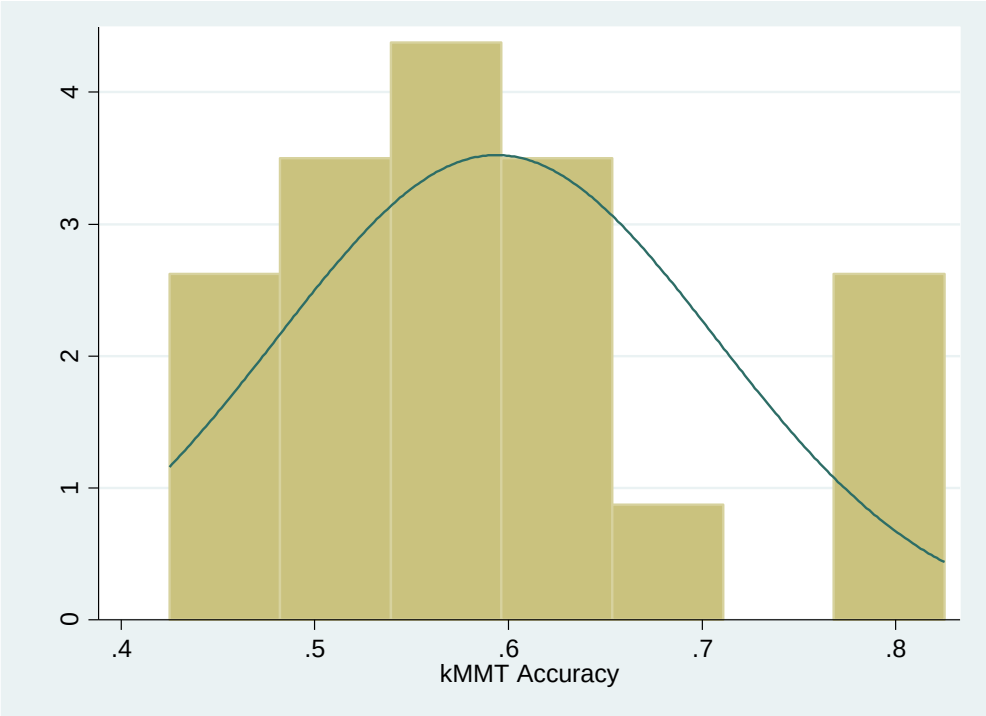
kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; *Significance reached

APPENDIX TABLE B.3.3 - Correlations among kMMT and Confidence Ratings.

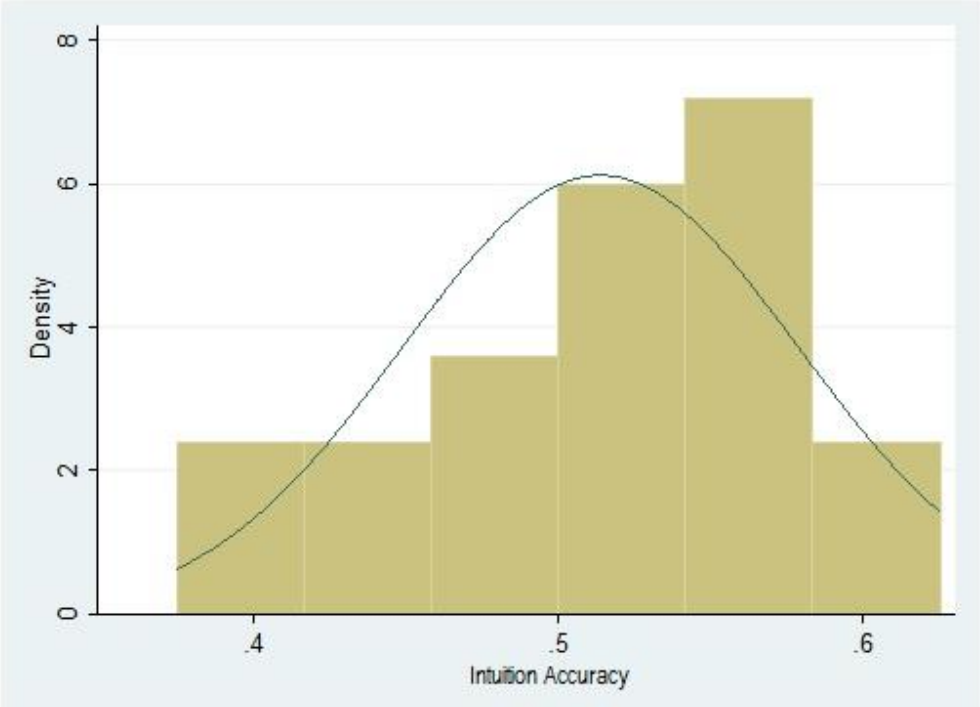
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1.	**Practitioner Confidence in OWN kMMT Ability: Pre-testing**	1.0000															
2.	**Practitioner Confidence in OWN kMMT Ability: Post-testing**	0.5674	1.0000														
		0.01															
3.	**Practitioner Confidence in kMMT in General: Pre-testing**	0.2221	0.2341	1.0000													
		0.35	*0.32*														
4.	**Practitioner Confidence in kMMT in General: Post-testing**	0.0942	0.3186	0.8279	1.0000												
		0.69	*0.17*	*0.00*													
5.	**TP Confidence in kMMT in General: Pre-testing**	-0.1099	-0.1505	-0.4230	-0.2232	1.0000											
		0.64	*0.53*	*0.06*	*0.34*												
6.	**TP Confidence in Practitioner: Pre-testing**	0.2042	0.1625	-0.0989	-0.0069	0.5278	1.0000										
		0.3878	*0.4935*	*0.6782*	*0.9768*	*0.0168*											
7.	**TP Confidence in Practitioner's kMMT Ability: Pre-testing**	0.1331	0.0571	-0.2041	-0.1513	-0.0309	-0.0418	1.0000									
		0.58	*0.81*	*0.39*	*0.52*	*0.90*	*0.86*										
8.	**TP Confidence in kMMT in General: Post-testing**	0.1815	0.0699	-0.2721	0.0718	0.3435	0.1094	-0.2126	1.0000								
		0.44	*0.77*	*0.25*	*0.76*	*0.14*	*0.65*	*0.37*									
9.	**TP Confidence in Practitioner: Post-testing**	-0.0268	0.0619	0.0207	0.2981	0.3493	0.3288	-0.1304	0.6457	1.0000							
		0.91	*0.80*	*0.93*	*0.20*	*0.13*	*0.16*	*0.58*	*<0.01*								
10.	**TP Confidence in Practitioner's kMMT Ability: Post-testing**	0.1945	0.2371	0.0934	0.2836	0.2971	0.5095	-0.1297	0.5842	0.7810	1.0000						
		0.41	*0.31*	*0.70*	*0.23*	*0.20*	*0.02*	*0.59*	*0.01*	*<0.01*							
11.	**Difference in Practitioner Confidence in OWN kMMT Ability: Post- – Pre-testing**	-0.2919	0.6220	0.0608	0.2806	-0.0703	-0.0054	-0.0602	-0.0914	0.0973	0.0905	1.0000					
		0.21	*<0.01*	*0.80*	*0.23*	*0.77*	*0.98*	*0.80*	*0.70*	*0.68*	*0.70*						
12.	**Difference in Practitioner Confidence in kMMT in General: Post- – Pre-testing**	-0.2560	0.0563	-0.5520	0.0106	0.4224	0.1661	0.1389	0.5919	0.4063	0.2551	0.3088	1.0000				
		0.28	*0.81*	*0.01*	*0.96*	*0.06*	*0.48*	*0.56*	*0.01*	*0.08*	*0.28*	*0.19*					
13.	**Difference in TP Confidence in kMMT in General: Post- – Pre-testing**	0.2523	0.1943	0.1497	0.2611	-0.6074	-0.3815	-0.1521	0.5374	0.2325	0.2274	-0.0142	0.1213	1.0000			
		0.28	*0.41*	*0.53*	*0.27*	*<0.01*	*0.10*	*0.52*	*0.01*	*0.32*	*0.34*	*0.95*	*0.61*				
14.	**Difference in TP Confidence in Practitioner: Post- – Pre-testing**	-0.1819	-0.0665	0.0955	0.2860	-0.0764	-0.4581	-0.0907	0.5238	0.6889	0.3440	0.0958	0.2549	0.5117	1.0000		
		0.44	*0.78*	*0.69*	*0.22*	*0.75*	*0.04*	*0.70*	*0.02*	*<0.01*	*0.14*	*0.69*	*0.28*	*0.02*			
15.	**Difference in TP Confidence in Practitoner's kMMT Ability: Post- – Pre-testing**	-0.0738	0.0081	0.2146	0.2145	0.1057	0.1709	-0.9665	0.3496	0.3238	0.3799	0.0796	-0.0636	0.2007	0.1737	1.0000	
		0.76	*0.97*	*0.36*	*0.36*	*0.66*	*0.47*	*<0.01*	*0.13*	*0.16*	*0.10*	*0.74*	*0.79*	*0.40*	*0.46*		
16.	**kMMT Accuracy**	0.0885	-0.1439	0.2757	-0.0763	-0.2971	0.0151	-0.3695	-0.1451	-0.2646	0.0379	-0.2513	-0.6049	0.1441	-0.2606	0.3546	1.0000
		0.71	*0.55*	*0.24*	*0.75*	*0.20*	*0.95*	*0.11*	*0.54*	*0.26*	*0.87*	*0.29*	*<0.01*	*0.54*	*0.27*	*0.13*	

kMMT, kinesiology-style manual muscle testing; TP, Test Patient; = Corre) reached significance (p <0.05); = kMMT Accuracy lations (r) reached significance.

APPENDIX FIGURE B.3.1 - Histograms showing normal distribution.

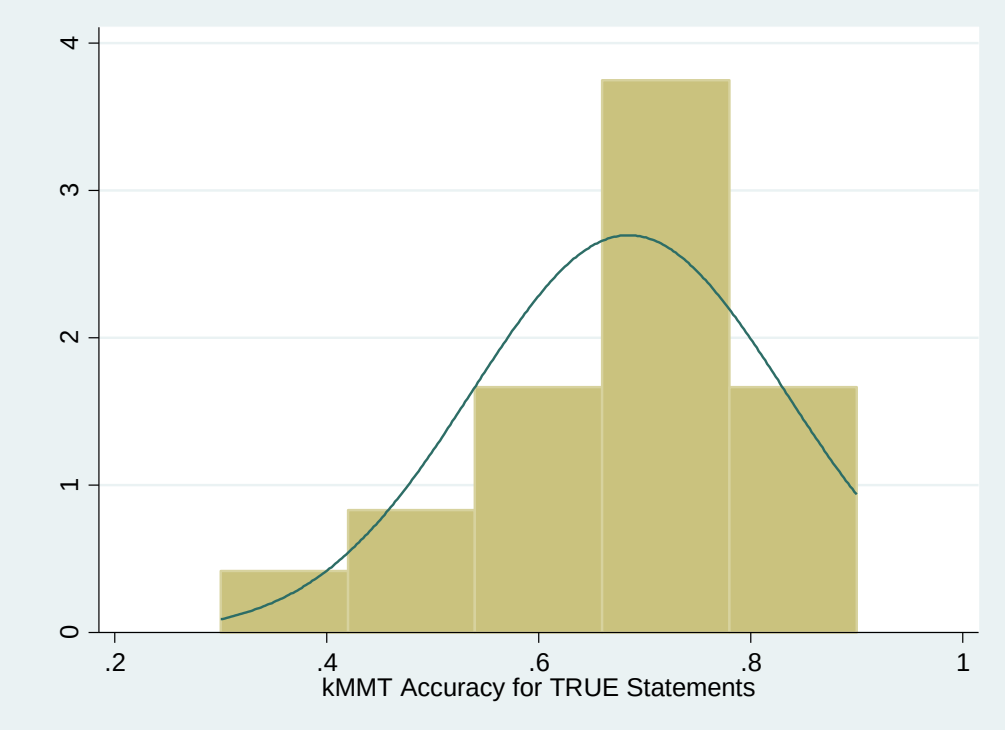


(A)

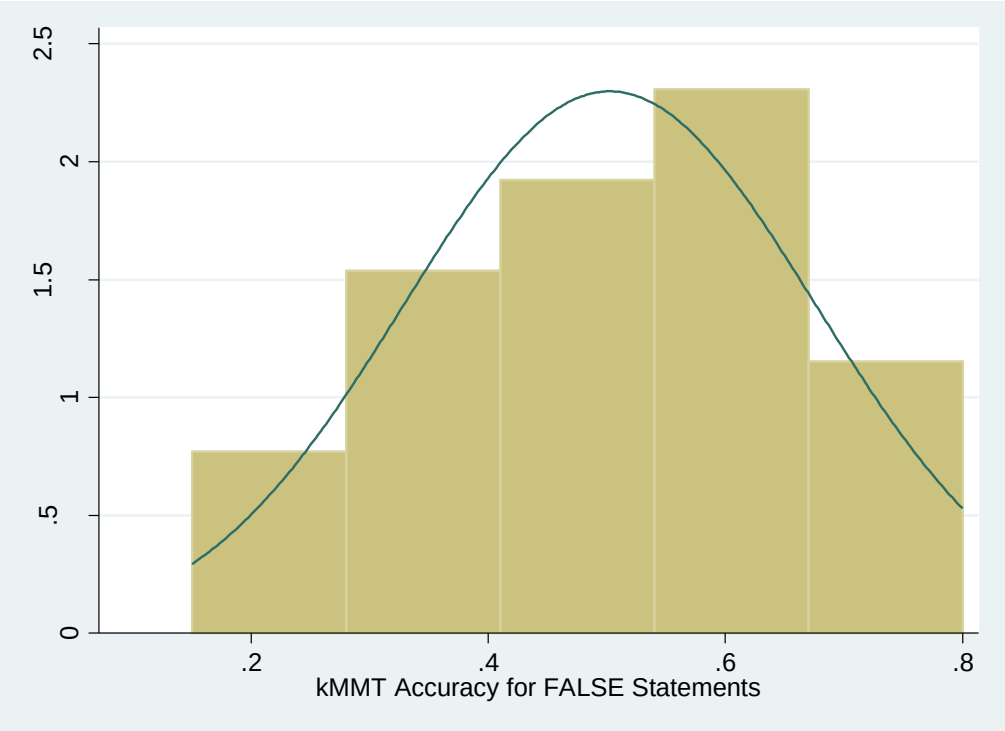


(B)

APPENDIX FIGURE B.3.1 (con't.)

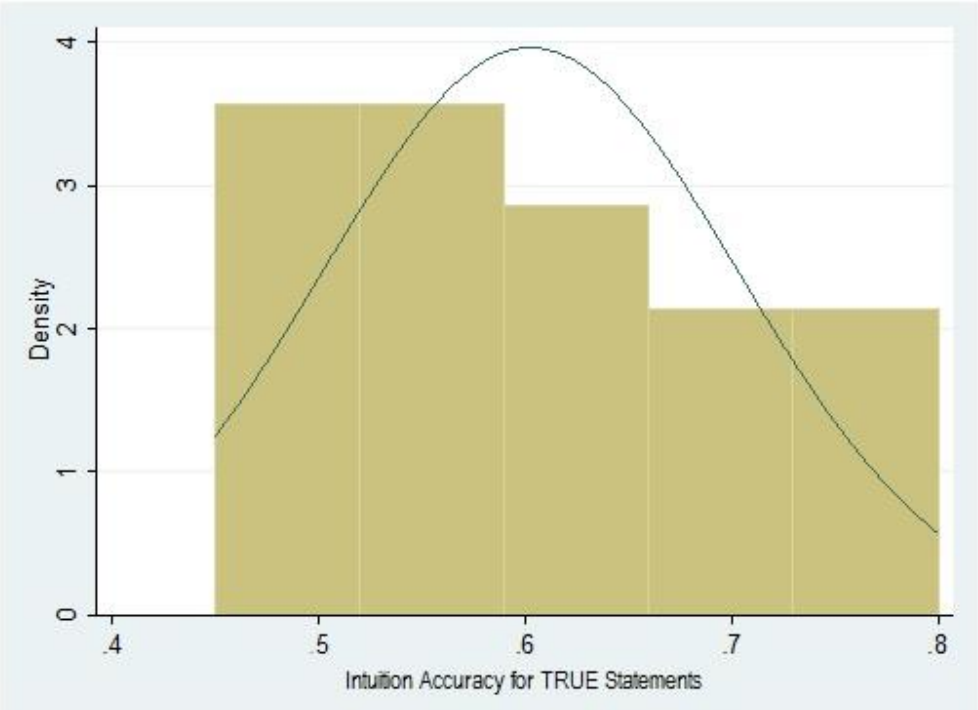


(C)



(D)

APPENDIX FIGURE B.3.1 (con't.)



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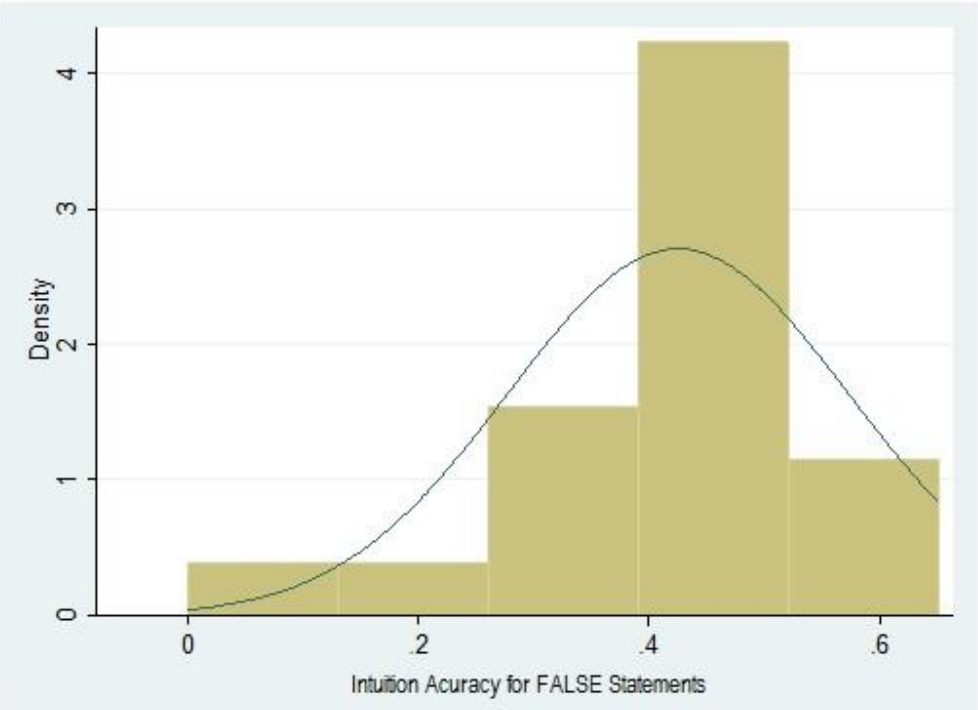
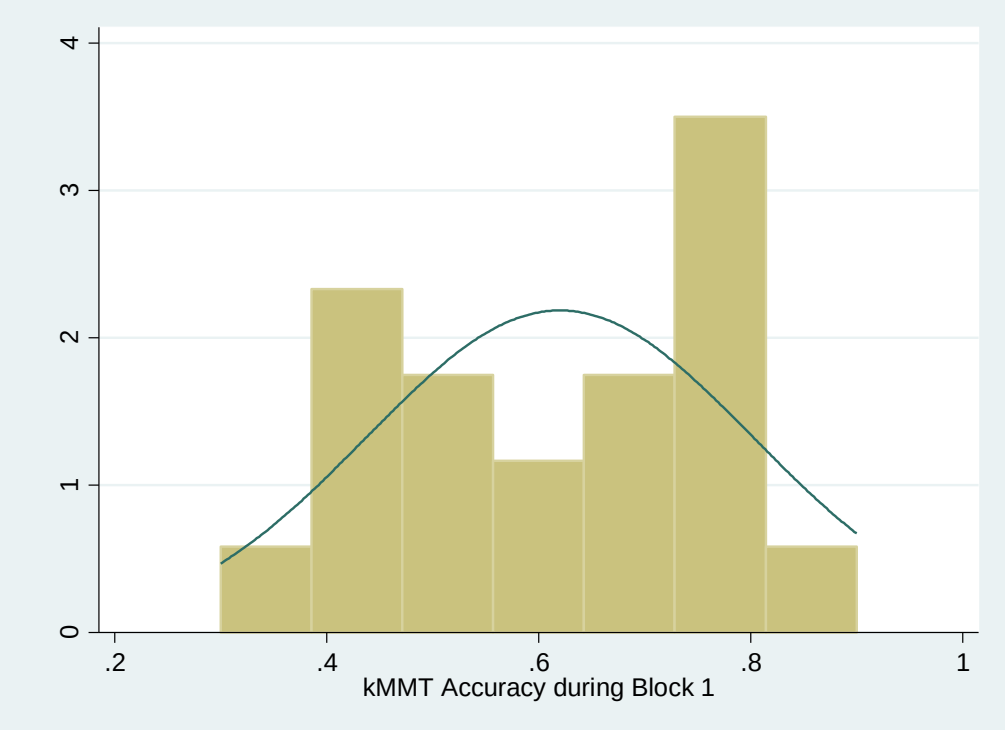
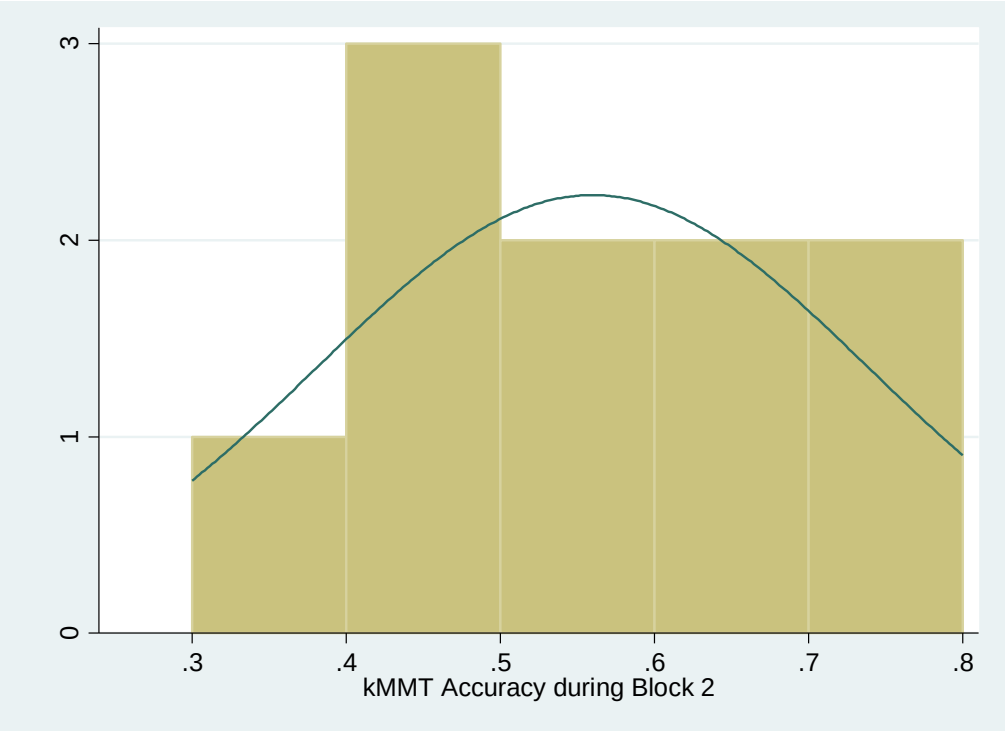


(F)

APPENDIX FIGURE B.3.1 (con't.)

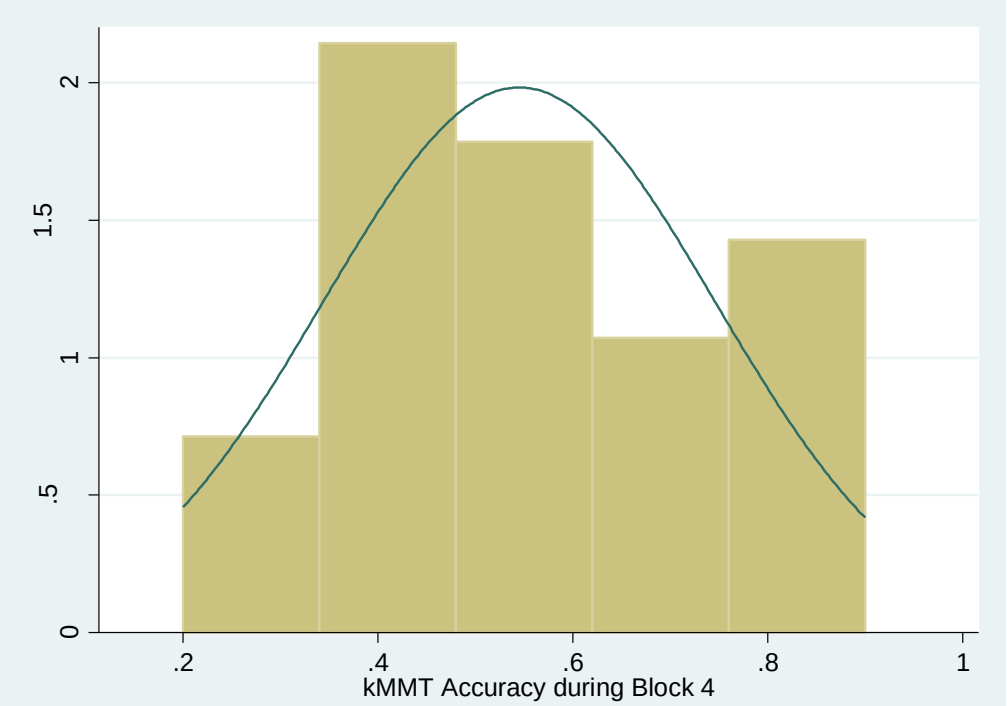


(G)

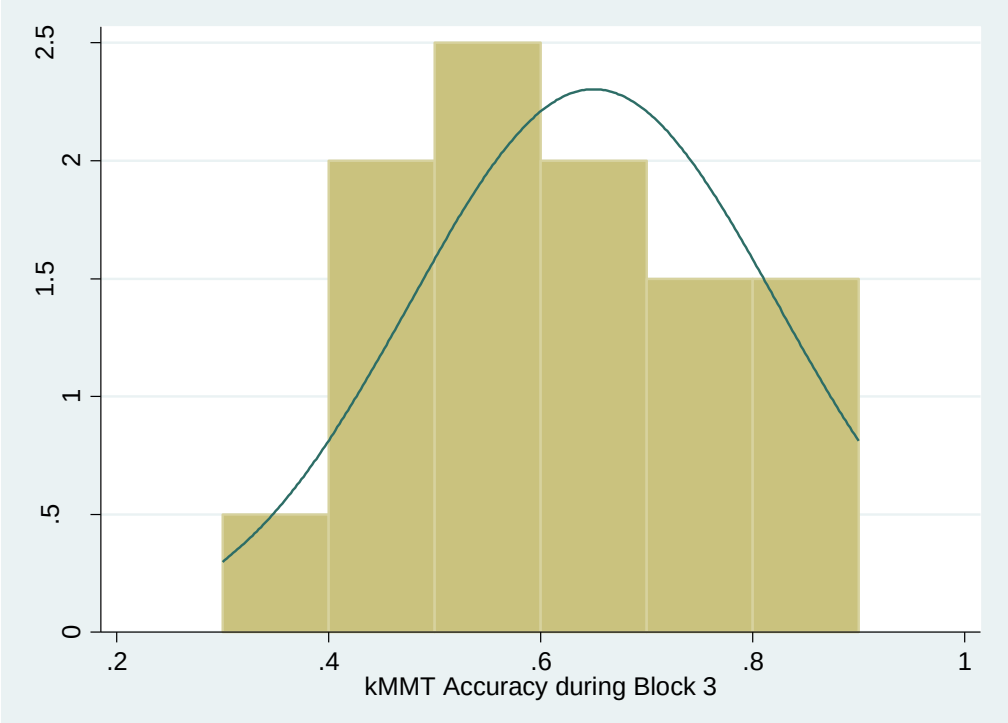


(H)

APPENDIX FIGURE B.3.1 (con't.)



(I)



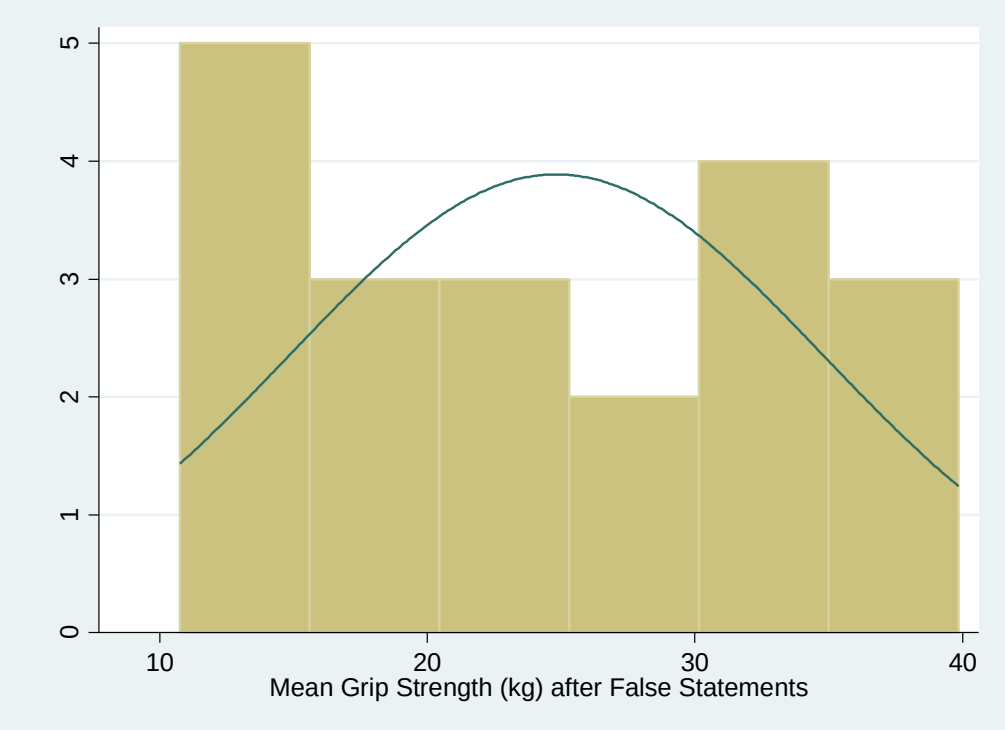
(J)

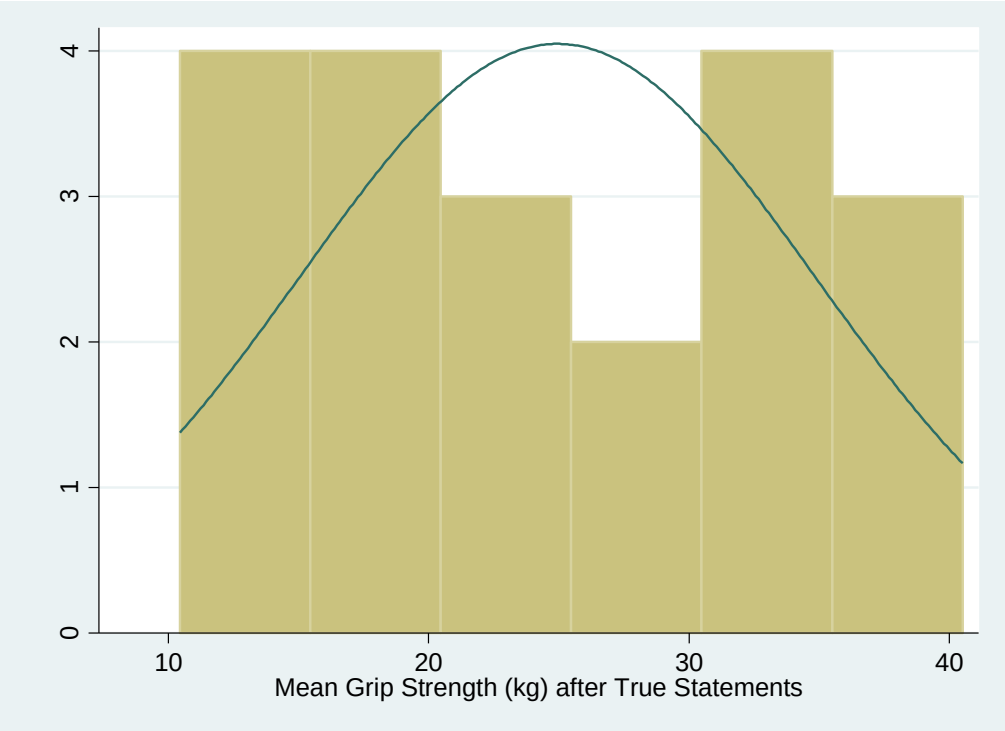
APPENDIX TABLE B.4.1 - Mean grip strengths (SD) by participant. (A) False vs. True statements, and (B) dominant hand vs. non-dominant hand.

	(A) Grip Strength by Statement Verity (kg)				(B) Grip Strength by Hand (kg)			
	False Statements		True Statements		Dominant Hand		Non-Dominant Hand	
Participant #	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	39.9	2.8	40.5	3.4	42.3	2.6	38.1	1.7
2	33.4	2.5	33.2	2.5	33.9	2.2	32.8	2.6
3	23.5	2.6	23.4	3.8	22.6	3.6	24.3	2.7
4	18.8	1.7	19.7	1.8	18.3	1.1	20.2	1.8
5	28.3	2.6	28.7	2.9	27.3	2.2	29.8	2.7
6	15.3	2.0	17.3	2.7	14.9	2.3	17.7	2.0
7	12.9	2.1	12.3	2.3	10.8	1.2	14.4	1.2
8	10.8	1.3	10.5	1.1	10.1	1.2	11.1	0.9
9	15.9	3.0	18.0	4.3	14.3	1.3	19.6	3.6
10	24.7	2.8	25.4	2.5	23.6	2.6	26.6	1.8
11	15.3	2.3	16.4	2.0	16.9	2.0	14.8	1.9
12	33.6	5.2	33.1	4.2	29.5	3.1	37.2	1.8
13	33.1	3.7	34.5	3.5	31.4	2.5	36.3	2.8
14	24.0	3.7	22.3	3.5	23.3	2.6	23.0	4.5
15	27.6	2.6	27.8	3.0	25.7	1.6	29.6	2.3
16	39.8	5.9	38.9	9.1	35.5	3.5	43.2	8.6
17	15.7	1.8	14.7	1.9	15.2	1.9	15.3	1.9
18	11.2	1.7	10.6	1.1	10.2	1.4	11.6	1.2
19	38.9	2.1	39.5	2.6	39.1	2.2	39.3	2.5
20	34.1	4.8	32.3	3.8	30.0	3.5	36.4	2.4

kg, Kilogram; SD, Standard Deviation.

APPENDIX FIGURE B.4.1 – Histograms.





APPENDIX TABLE B.5.1- Accuracy Data for each Pair: Accuracy (Overall Percent Correct), Sensitivity, Specificity, PPV and NPV; for kMMT and Intuition.

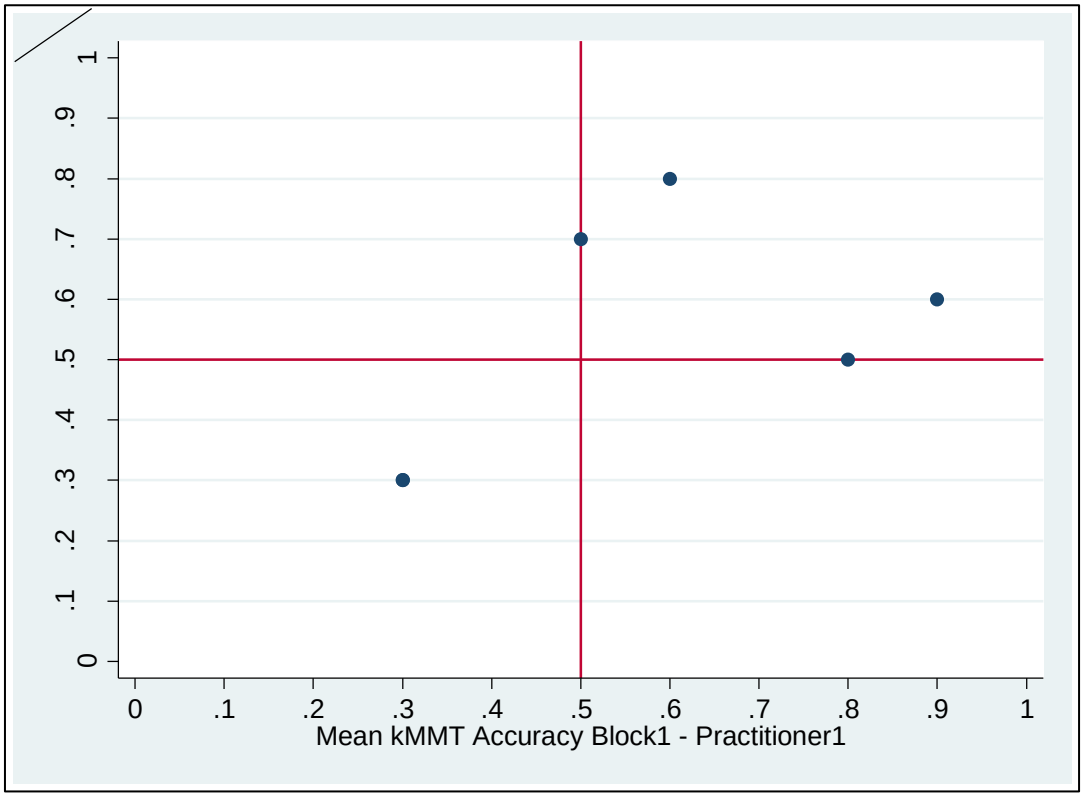
			kMMT					Intution				
Pair	**TP**	**Practitioner**	**Accuracy***	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy***	**Sensitivity**	**Specificity**	**PPV**	**NPV**
1	1	1	0.750	0.600	0.900	0.857	0.692	0.400	0.300	0.500	0.375	0.417
2	1	2	0.350	0.500	0.200	0.385	0.286	0.450	0.600	0.300	0.462	0.429
3	1	3	0.750	0.600	0.900	0.857	0.692	0.350	0.300	0.400	0.333	0.364
4	1	4	0.550	0.600	0.500	0.545	0.556	0.550	0.500	0.600	0.556	0.545
5	1	5	0.900	1.000	0.800	0.833	1.000	0.600	0.500	0.700	0.625	0.583
6	1	6	0.950	0.900	1.000	1.000	0.909	0.600	0.700	0.500	0.583	0.625
7	1	7	0.850	0.800	0.900	0.889	0.818	0.450	0.400	0.500	0.444	0.455
8	1	8	1.000	1.000	1.000	1.000	1.000	0.500	0.400	0.600	0.500	0.500
9	1	9	0.500	0.300	0.700	0.500	0.500	0.700	0.500	0.900	0.833	0.643
10	1	10	0.450	0.400	0.500	0.444	0.455	0.450	0.400	0.500	0.444	0.455
11	1	11	0.500	0.600	0.400	0.500	0.500	0.450	0.400	0.500	0.444	0.455
12	1	12	0.950	0.900	1.000	1.000	0.909	0.500	0.400	0.600	0.500	0.500
13	1	13	0.900	1.000	0.800	0.833	1.000	0.450	0.444	0.455	0.400	0.500
14	1	14	1.000	1.000	1.000	1.000	1.000	0.650	0.600	0.700	0.667	0.636
15	1	15	0.600	0.200	1.000	1.000	0.556	0.400	0.300	0.500	0.375	0.417
16	1	16	0.650	0.500	0.800	0.714	0.615	0.550	0.500	0.600	0.556	0.545
17	2	1	0.300	0.300	0.300	0.300	0.300	0.600	0.700	0.500	0.583	0.625
18	2	2	0.400	0.500	0.300	0.417	0.375	0.450	0.222	0.636	0.333	0.500
19	2	3	0.650	0.600	0.700	0.667	0.636	0.250	0.200	0.300	0.222	0.273
20	2	4	0.450	0.778	0.182	0.438	0.500	0.500	0.500	0.500	0.500	0.500
21	2	5	0.550	0.700	0.400	0.538	0.571	0.550	0.556	0.545	0.500	0.600
22	2	6	0.650	0.667	0.636	0.600	0.700	0.500	0.700	0.300	0.500	0.500
23	2	7	0.650	0.500	0.800	0.714	0.615	0.500	0.500	0.500	0.500	0.500
24	2	8	0.800	1.000	0.600	0.714	1.000	0.700	0.700	0.700	0.700	0.700
25	2	9	0.600	0.778	0.455	0.538	0.714	0.500	0.333	0.636	0.429	0.538
26	2	10	0.250	0.300	0.200	0.273	0.222	0.500	0.400	0.600	0.500	0.500
27	2	11	0.450	0.800	0.100	0.471	0.333	0.550	0.500	0.600	0.556	0.545
28	2	12	0.700	0.700	0.700	0.700	0.700	0.450	0.500	0.400	0.455	0.444
29	2	13	0.900	0.900	0.900	0.900	0.900	0.550	0.400	0.700	0.571	0.538
30	2	14	0.700	0.778	0.636	0.636	0.778	0.150	0.200	0.100	0.182	0.111
31	2	15	0.550	0.700	0.400	0.538	0.571	0.250	0.200	0.300	0.222	0.273
32	2	16	0.550	0.375	0.667	0.429	0.615	0.500	0.300	0.700	0.500	0.500
33	3	1	0.600	0.700	0.500	0.583	0.625	0.500	0.500	0.500	0.500	0.500
34	3	2	0.600	0.500	0.700	0.625	0.583	0.350	0.300	0.400	0.333	0.364
35	3	3	0.550	0.300	0.800	0.600	0.533	0.300	0.200	0.400	0.250	0.333
36	3	4	0.800	0.800	0.800	0.800	0.800	0.600	0.500	0.700	0.625	0.583
37	3	5	0.750	0.600	0.900	0.857	0.692	0.650	0.500	0.800	0.714	0.615
38	3	6	0.600	0.300	0.900	0.750	0.563	0.400	0.444	0.364	0.364	0.444
39	3	7	0.600	0.400	0.800	0.667	0.571	0.500	0.400	0.600	0.500	0.500
40	3	8	0.850	0.800	0.900	0.889	0.818	0.550	0.400	0.700	0.571	0.538
41	3	9	0.450	0.200	0.700	0.400	0.467	0.450	0.500	0.400	0.455	0.444
42	3	10	0.700	0.500	0.900	0.833	0.643	0.550	0.500	0.600	0.556	0.545
43	3	11	0.800	0.667	0.909	0.857	0.769	0.450	0.300	0.600	0.429	0.462
44	3	12	0.800	0.667	0.909	0.857	0.769	0.400	0.500	0.300	0.417	0.375
45	3	13	0.700	0.500	0.900	0.833	0.643	0.650	0.500	0.800	0.714	0.615
46	3	14	0.850	0.700	1.000	1.000	0.769	0.650	0.800	0.500	0.615	0.714
47	3	15	0.750	0.600	0.900	0.857	0.692	0.400	0.300	0.500	0.375	0.417
48	3	16	0.350	0.200	0.500	0.286	0.385	0.500	0.200	0.800	0.500	0.500
49	4	1	0.650	0.700	0.600	0.636	0.667	0.450	0.600	0.300	0.462	0.429
50	4	2	0.600	0.700	0.500	0.583	0.625	0.600	0.400	0.800	0.667	0.571
51	4	3	0.550	0.400	0.700	0.571	0.538	0.450	0.300	0.600	0.429	0.462
52	4	4	0.800	0.700	0.900	0.875	0.750	0.400	0.400	0.400	0.400	0.400
53	4	5	0.500	0.600	0.400	0.500	0.500	0.450	0.300	0.600	0.429	0.462
54	4	6	0.650	0.600	0.700	0.667	0.636	0.650	0.600	0.700	0.667	0.636
55	4	7	0.650	0.600	0.700	0.667	0.636	0.550	0.600	0.500	0.545	0.556
56	4	8	0.750	0.800	0.700	0.727	0.778	0.600	0.600	0.600	0.600	0.600
57	4	9	0.500	0.500	0.500	0.500	0.500	0.600	0.600	0.600	0.600	0.600
58	4	10	0.500	0.400	0.600	0.500	0.500	0.500	0.400	0.600	0.500	0.500
59	4	11	0.700	0.600	0.800	0.750	0.667	0.400	0.222	0.545	0.286	0.462
60	4	12	0.600	0.500	0.700	0.625	0.583	0.650	0.600	0.700	0.667	0.636
61	4	13	0.400	0.100	0.700	0.250	0.438	0.800	0.700	0.900	0.875	0.750
62	4	14	0.450	0.300	0.600	0.429	0.462	0.450	0.444	0.455	0.400	0.500
63	4	15	0.450	0.200	0.700	0.400	0.467	0.600	0.600	0.600	0.600	0.600
64	4	16	0.350	0.200	0.500	0.286	0.385	0.600	0.500	0.700	0.625	0.583
65	5	1	0.300	0.222	0.364	0.222	0.364	0.550	0.700	0.400	0.538	0.571
66	5	2	0.500	0.600	0.400	0.500	0.500	0.550	0.600	0.500	0.545	0.556
67	5	3	0.450	0.700	0.200	0.467	0.400	0.600	0.400	0.800	0.667	0.571
68	5	4	0.400	0.700	0.100	0.438	0.250	0.600	0.600	0.600	0.600	0.600
69	5	5	0.350	0.500	0.200	0.385	0.286	0.600	0.600	0.600	0.600	0.600
70	5	6	0.600	0.500	0.700	0.625	0.583	0.500	0.500	0.500	0.500	0.500
71	5	7	0.350	0.400	0.300	0.364	0.333	0.600	0.400	0.800	0.667	0.571
72	5	8	0.400	0.800	0.000	0.444	0.000	0.400	0.300	0.500	0.375	0.417
73	5	9	0.450	0.600	0.300	0.462	0.429	0.250	0.300	0.200	0.273	0.222
74	5	10	0.600	0.444	0.727	0.571	0.615	0.450	0.400	0.500	0.444	0.455
75	5	11	0.300	0.556	0.091	0.333	0.200	0.500	0.400	0.600	0.500	0.500
76	5	12	0.500	0.400	0.600	0.500	0.500	0.350	0.200	0.500	0.286	0.385
77	5	13	0.550	0.375	0.667	0.429	0.615	0.300	0.100	0.500	0.167	0.357
78	5	14	0.350	0.500	0.200	0.385	0.286	0.450	0.500	0.400	0.455	0.444
79	5	15	0.150	0.100	0.200	0.111	0.182	0.450	0.400	0.500	0.444	0.455
80	5	16	0.450	0.200	0.700	0.400	0.467	0.450	0.300	0.600	0.429	0.462
81	6	1	0.700	0.778	0.636	0.636	0.778	0.750	0.800	0.700	0.727	0.778
82	6	2	0.550	0.700	0.400	0.538	0.571	0.600	0.400	0.800	0.667	0.571
83	6	3	0.850	0.800	0.900	0.889	0.818	0.400	0.300	0.500	0.375	0.417
84	6	4	0.700	0.889	0.545	0.615	0.857	0.600	0.500	0.700	0.625	0.583
85	6	5	0.550	0.700	0.400	0.538	0.571	0.450	0.300	0.600	0.429	0.462
86	6	6	0.850	0.900	0.800	0.818	0.889	0.500	0.500	0.500	0.500	0.500
87	6	7	0.850	0.800	0.900	0.889	0.818	0.600	0.400	0.800	0.667	0.571
88	6	8	0.950	1.000	0.900	0.909	1.000	0.500	0.333	0.636	0.429	0.538
89	6	9	0.800	0.700	0.900	0.875	0.750	0.600	0.667	0.545	0.545	0.667
90	6	10	0.650	0.500	0.800	0.714	0.615	0.400	0.444	0.364	0.364	0.444
91	6	11	0.800	1.000	0.600	0.714	1.000	0.700	0.800	0.600	0.667	0.750
92	6	12	0.850	0.700	1.000	1.000	0.769	0.600	0.500	0.700	0.625	0.583
93	6	13	0.800	0.600	1.000	1.000	0.714	0.450	0.400	0.500	0.444	0.455
94	6	14	0.600	0.600	0.600	0.600	0.600	0.650	0.900	0.400	0.600	0.800
95	6	15	0.600	0.700	0.500	0.583	0.625	0.550	0.500	0.600	0.556	0.545
96	6	16	0.700	0.500	0.900	0.833	0.643	0.550	0.444	0.636	0.500	0.583
		Mean	**0.616**	**0.595**	**0.638**	**0.632**	**0.609**	**0.507**	**0.456**	**0.557**	**0.502**	**0.514**
		SD	**0.186**	**0.224**	**0.258**	**0.215**	**0.207**	**0.114**	**0.155**	**0.150**	**0.135**	**0.112**
		95% CI	**0.578 - 0.654**	**0.549 - 0.640**	**0.585 - 0.690**	**0.588 - 0.676**	**0.567 - 0.652**	**0.484 - 0.530**	**0.424 - 0.487**	**0.527 - 0.588**	**0.475 - 0.530**	**0.491 - 0.537**

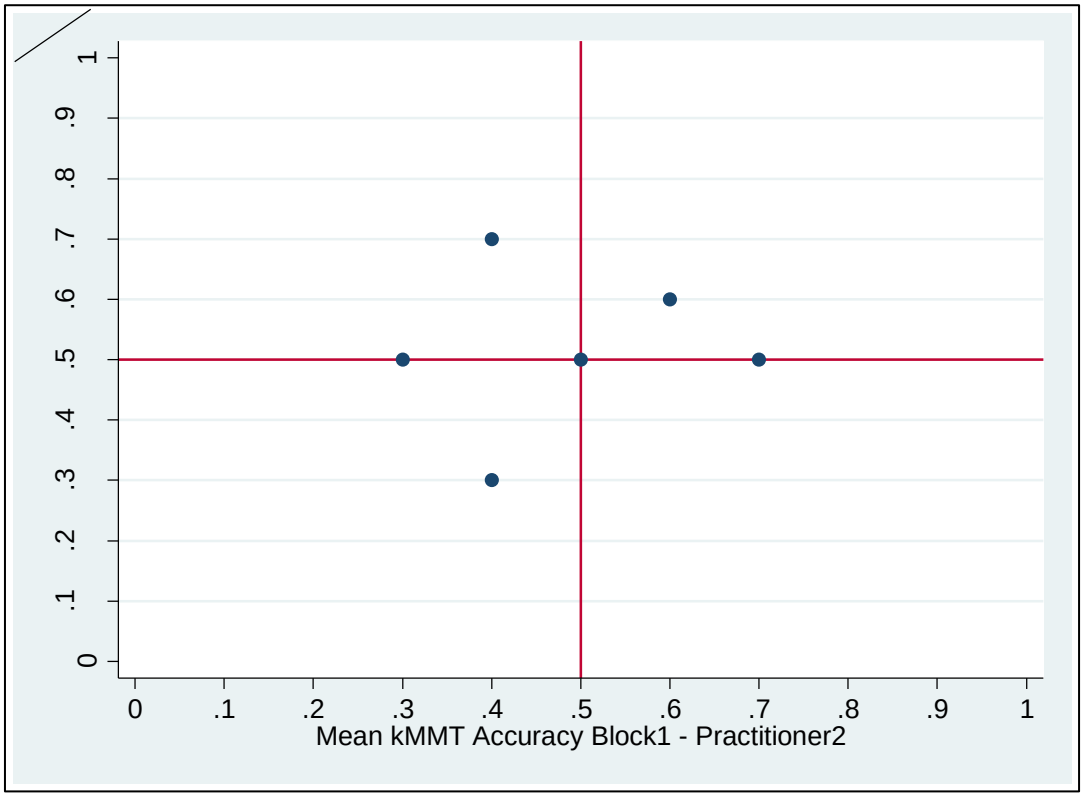
* Accuracy as Overall Percent Correct; kMMT, kinesiology-style manual muscle testing; TP, Test Patient; PPV, Positive Predictive Value; NPV, Negative Predictive Value; SD, Standard Deviation; CI, Confidence Interval.

APPENDIX TABLE B.5.2 - ANOVA results : Practitioner, TP & Block.

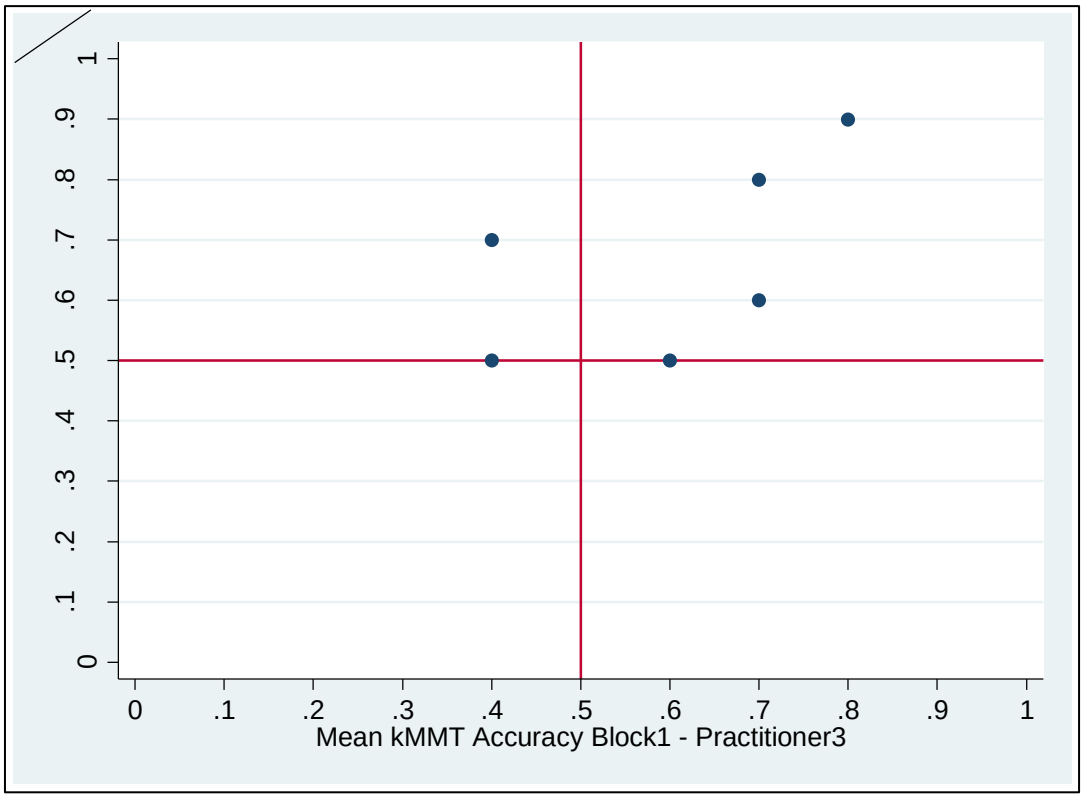
Source	Partial SS	df	F	Prob>F	%
Model	3.7930	21	6.31	<0.01	43.8%
Practitioner	1.4391	15	3.35	<0.01	16.6%
TP	2.3534	5	16.44	<0.01	27.2%
Block	0.0005	1	0.02	0.90	0.0%
Residual	4.8670	170			56.2%
Total	8.6599	191			100.0%

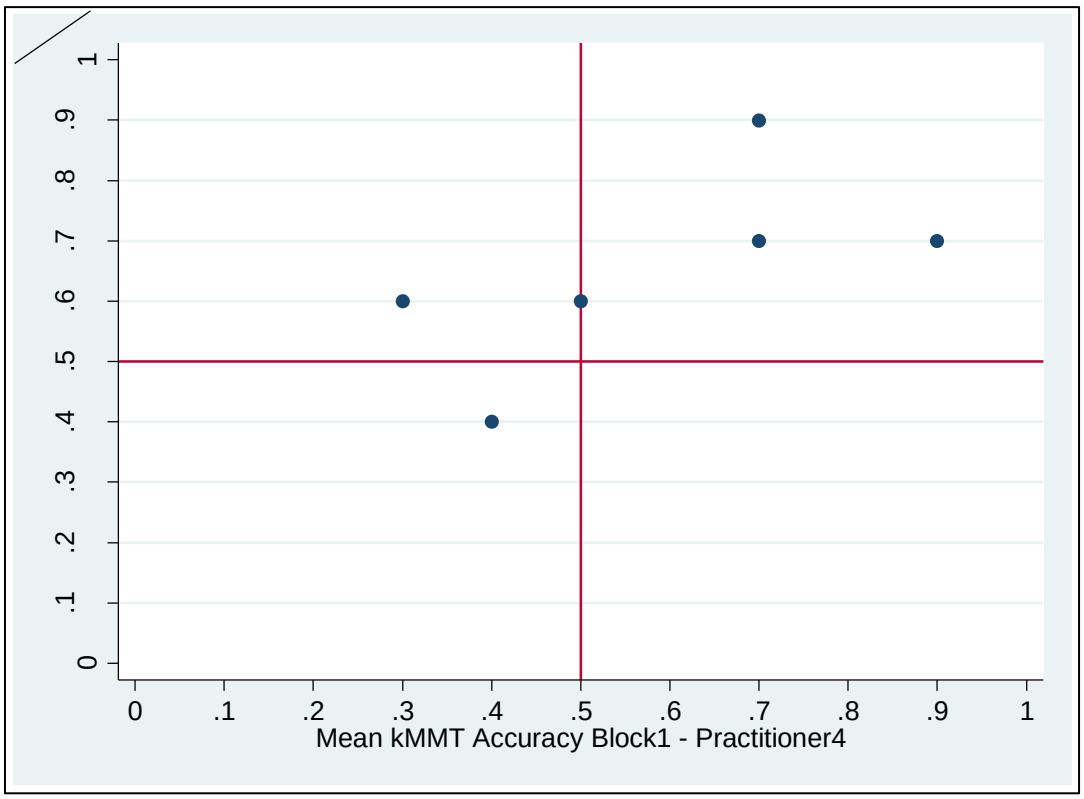
APPENDIX FIGURE B.5.1 - Repeatability Scatterplots : Block 1 vs Block 2 – by Practitioner (#1-16).



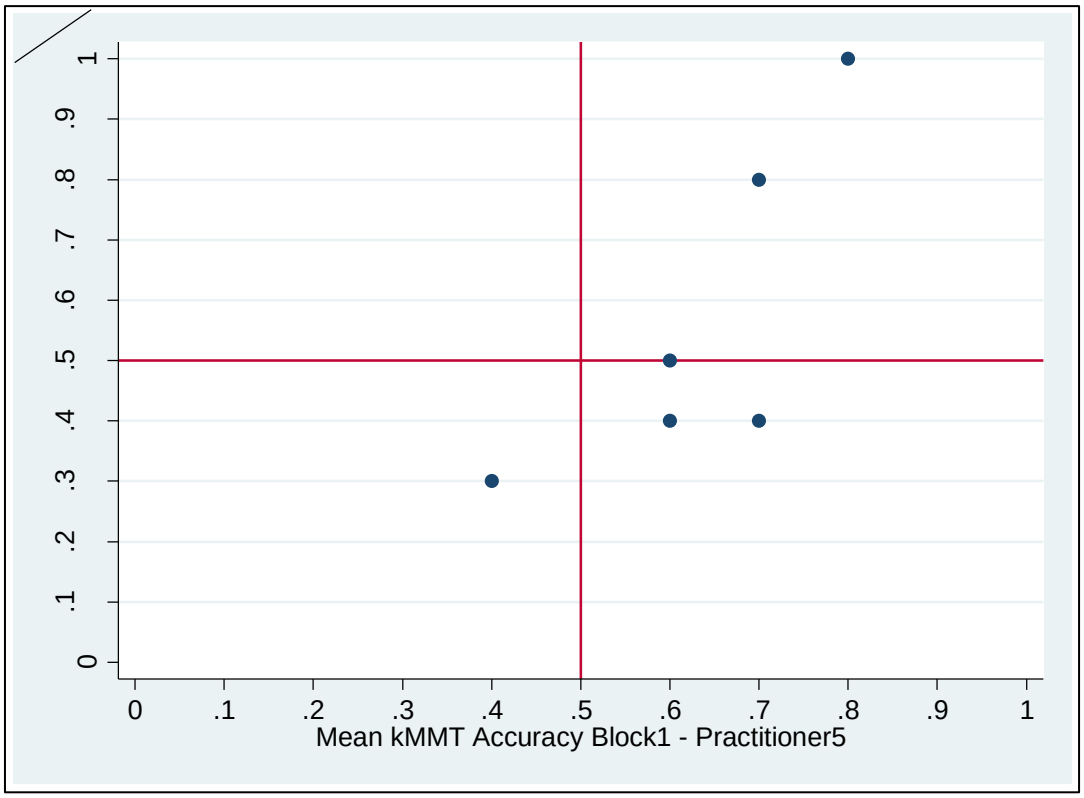


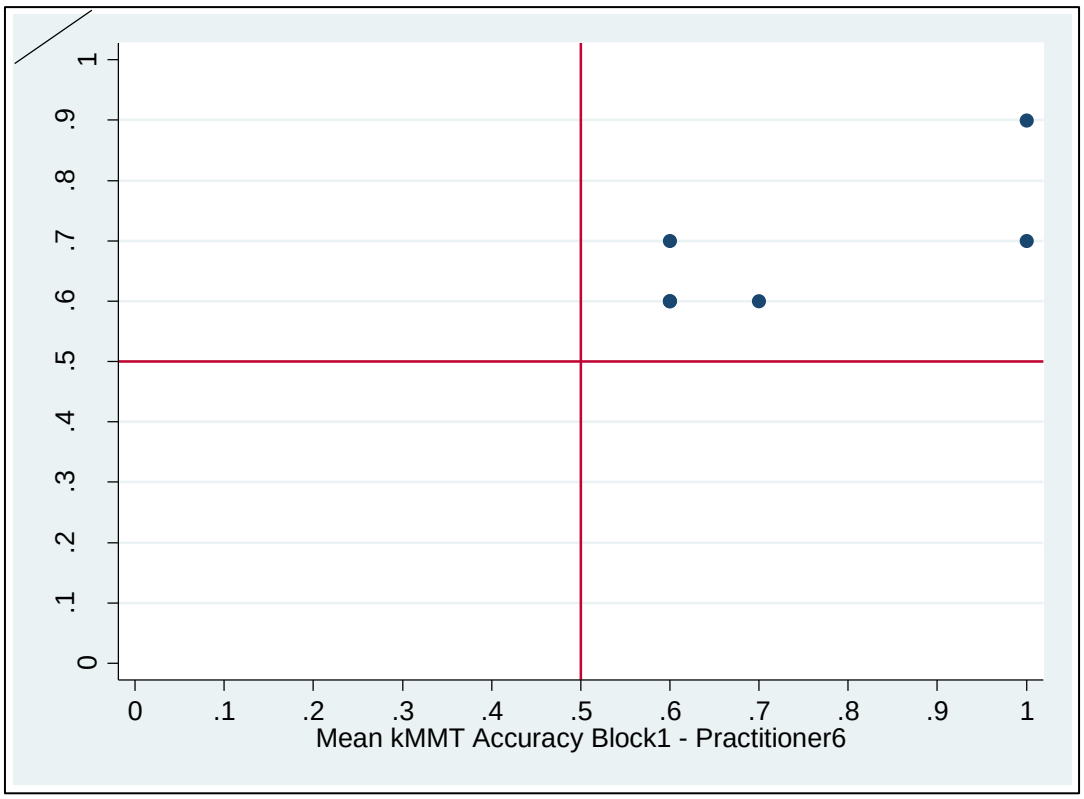
APPENDIX FIGURE B.5.1 (con't.)



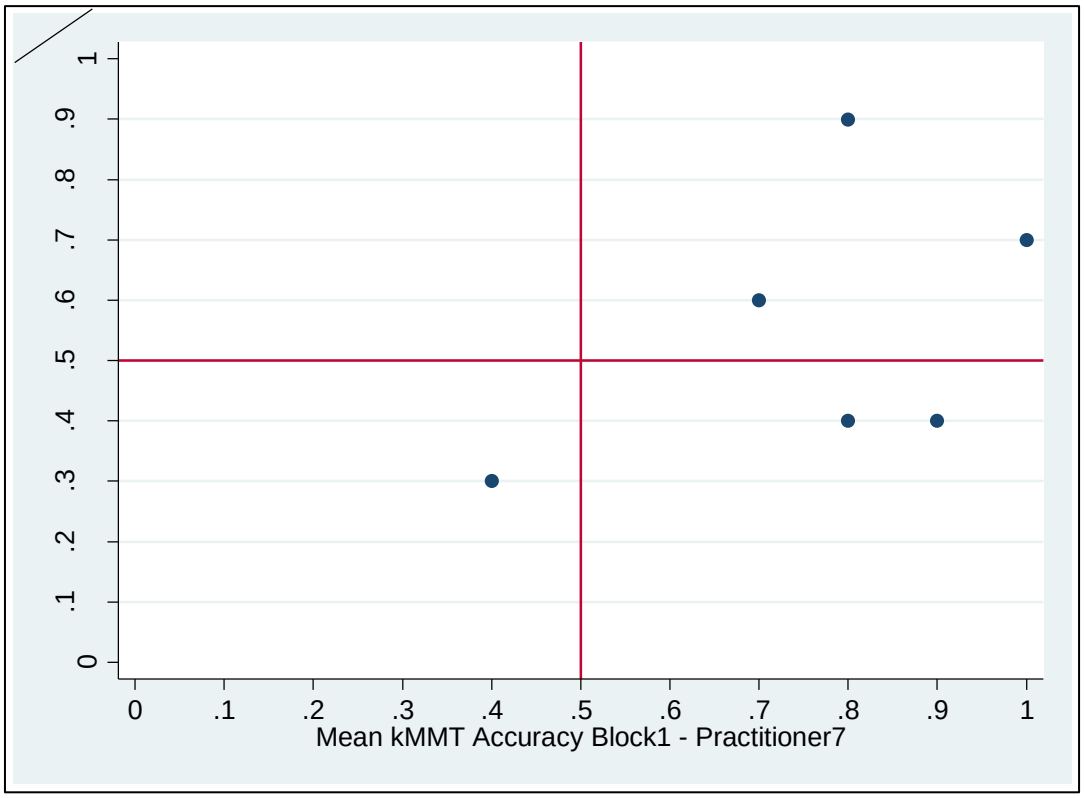


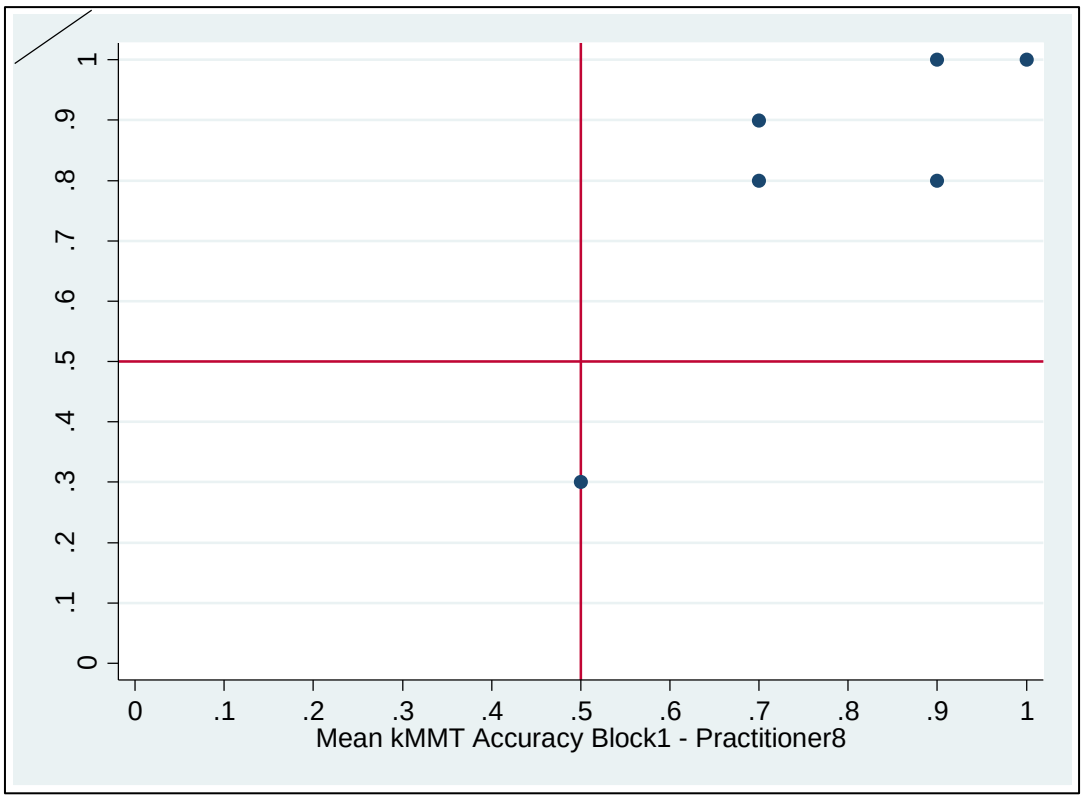
APPENDIX FIGURE B.5.1 (con't.)



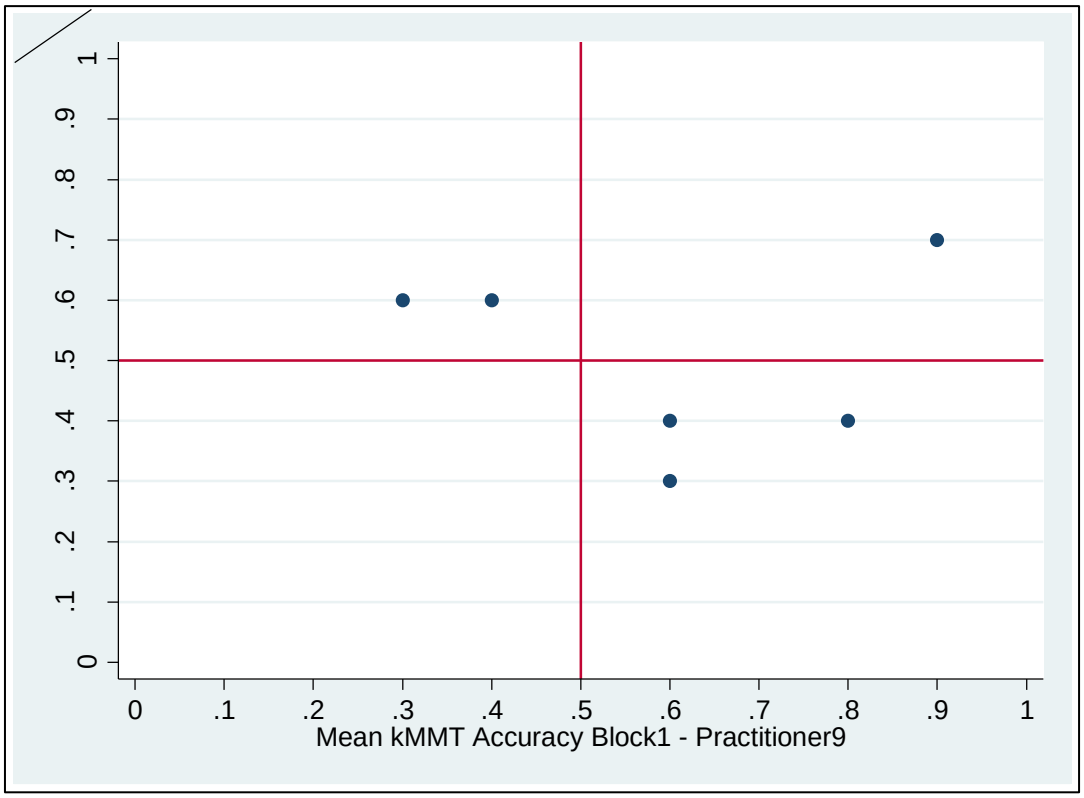


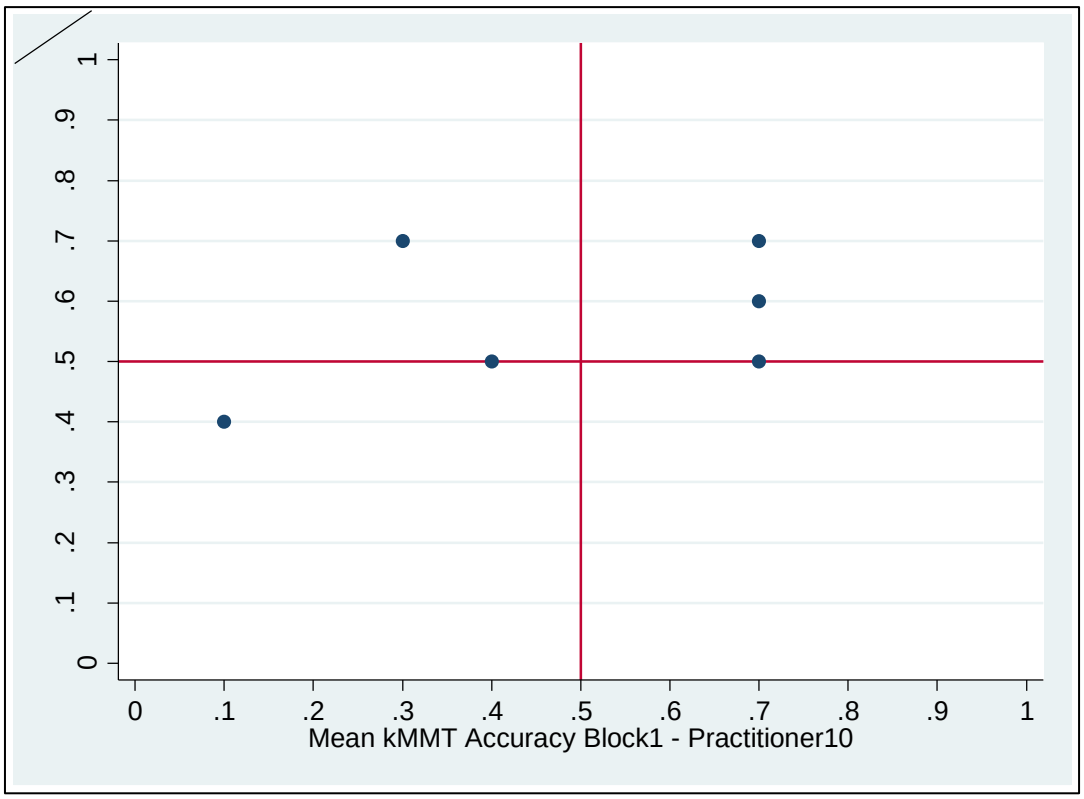
APPENDIX FIGURE B.5.1 (con't.)



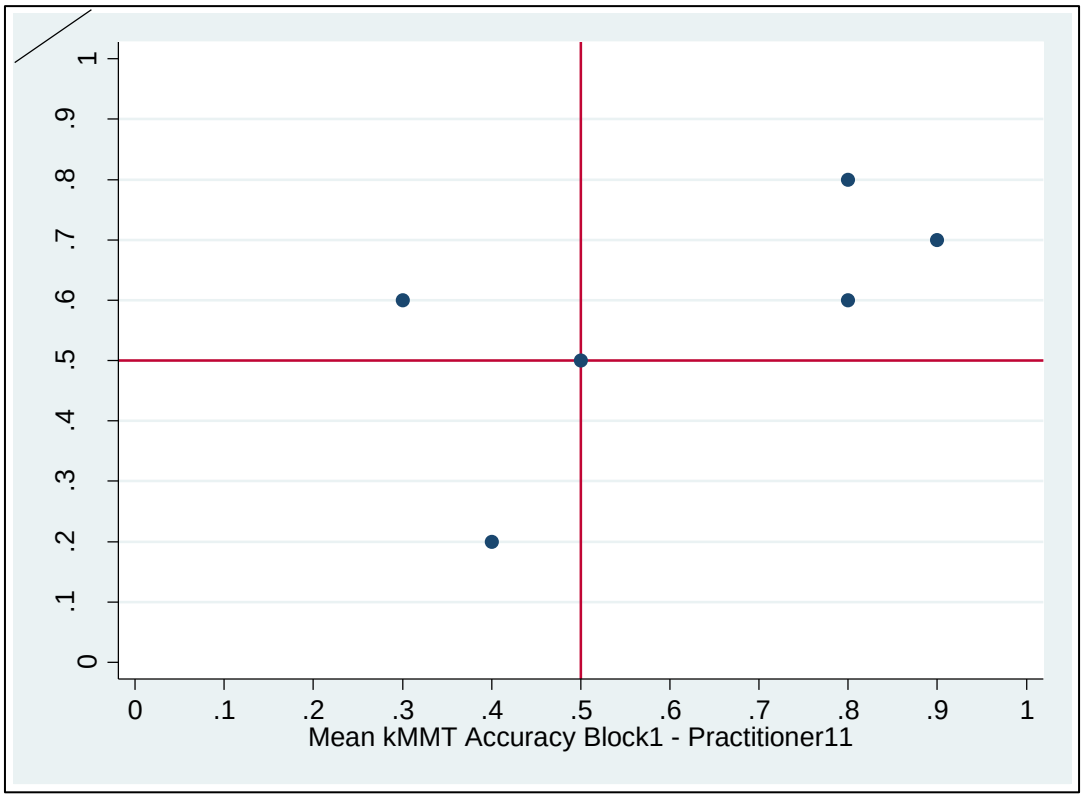


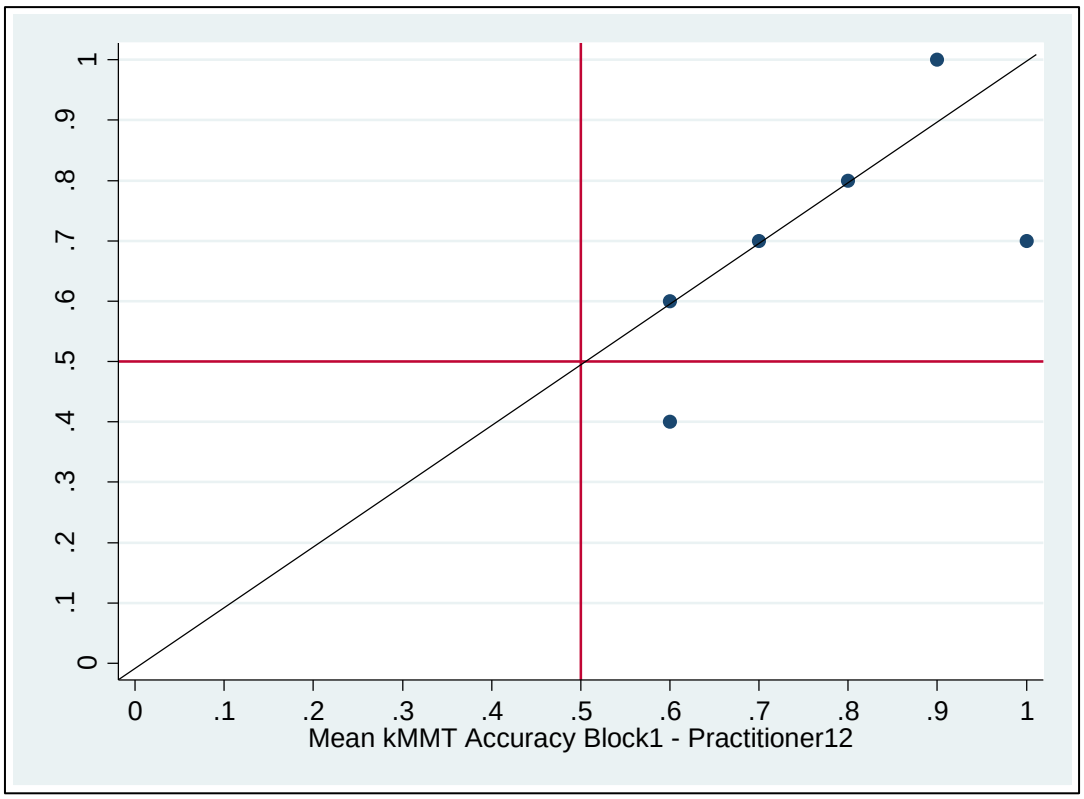
APPENDIX FIGURE B.5.1 (con't.)



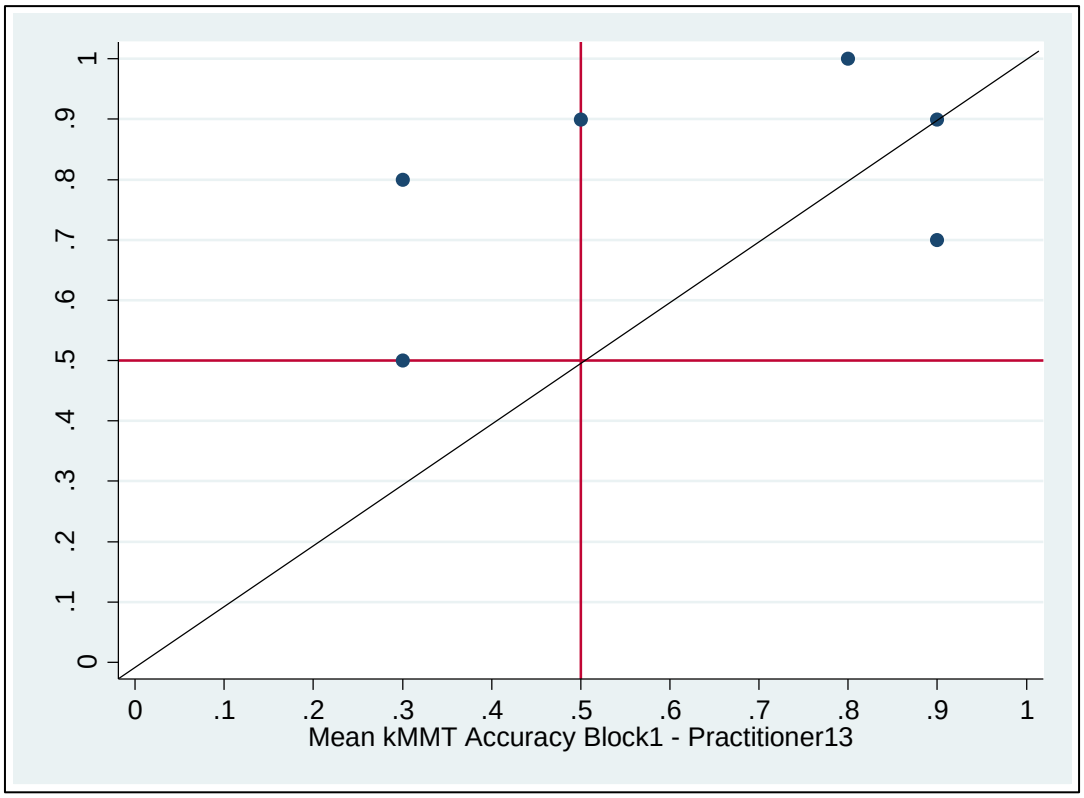


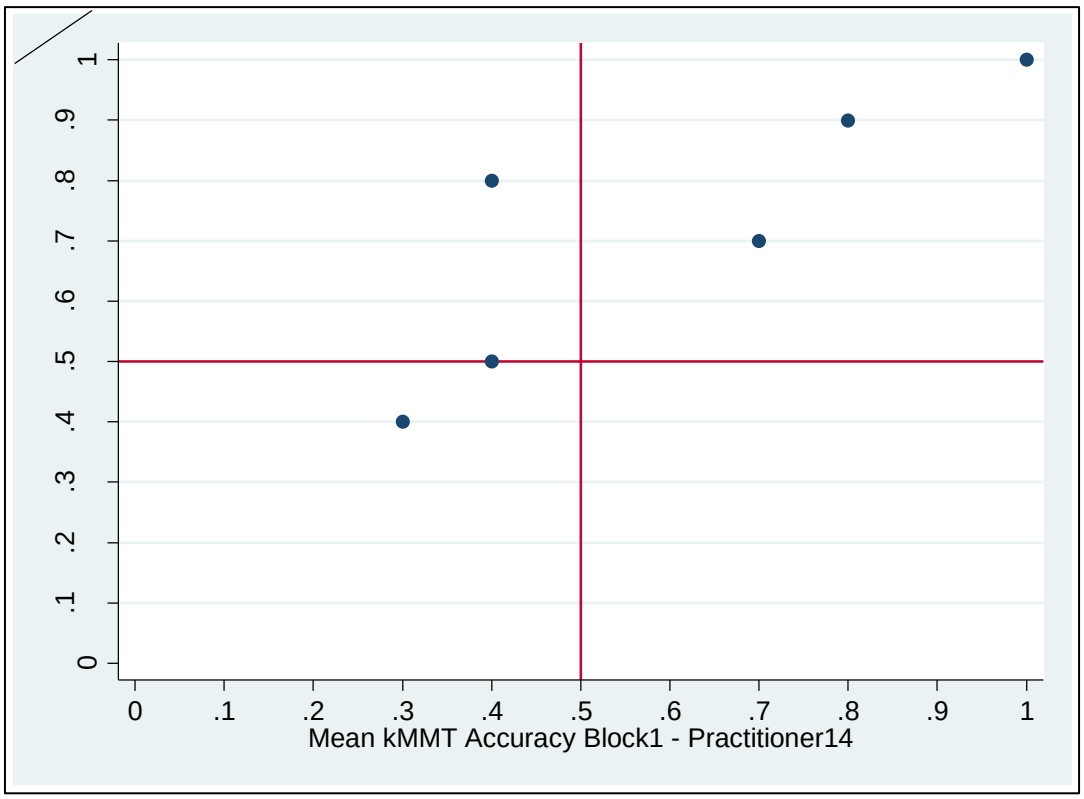
APPENDIX FIGURE B.5.1 (con't.)



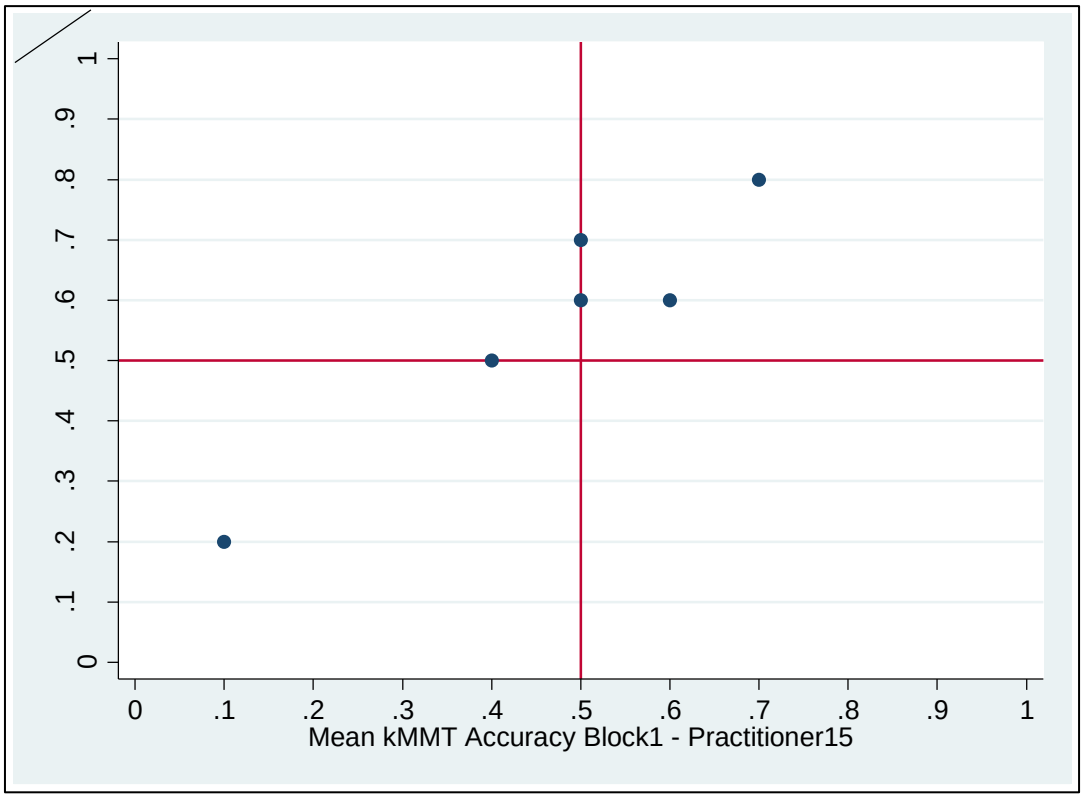


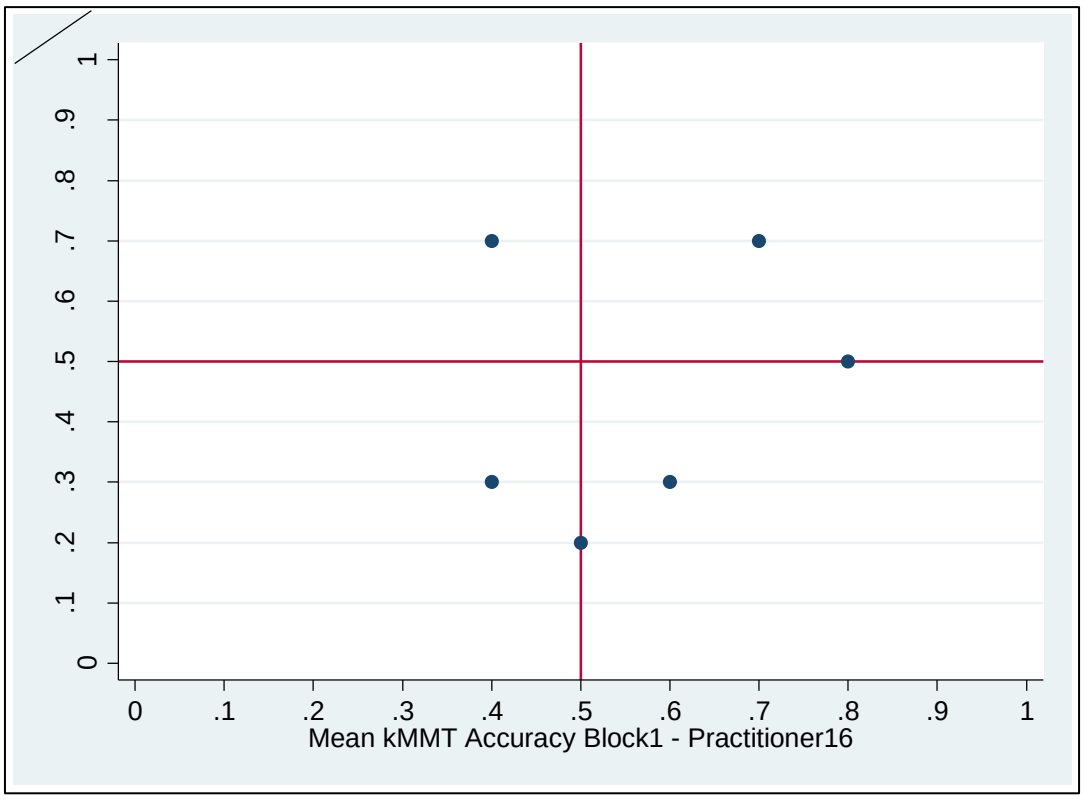
APPENDIX FIGURE B.5.1 (con't.)



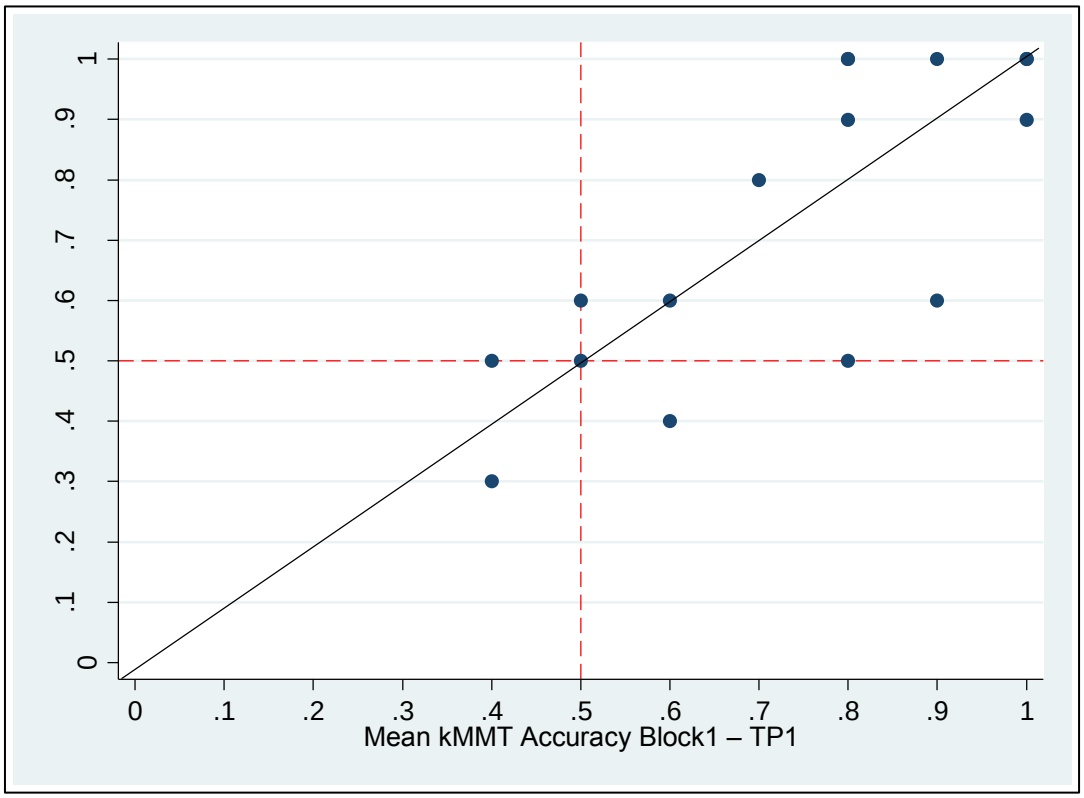


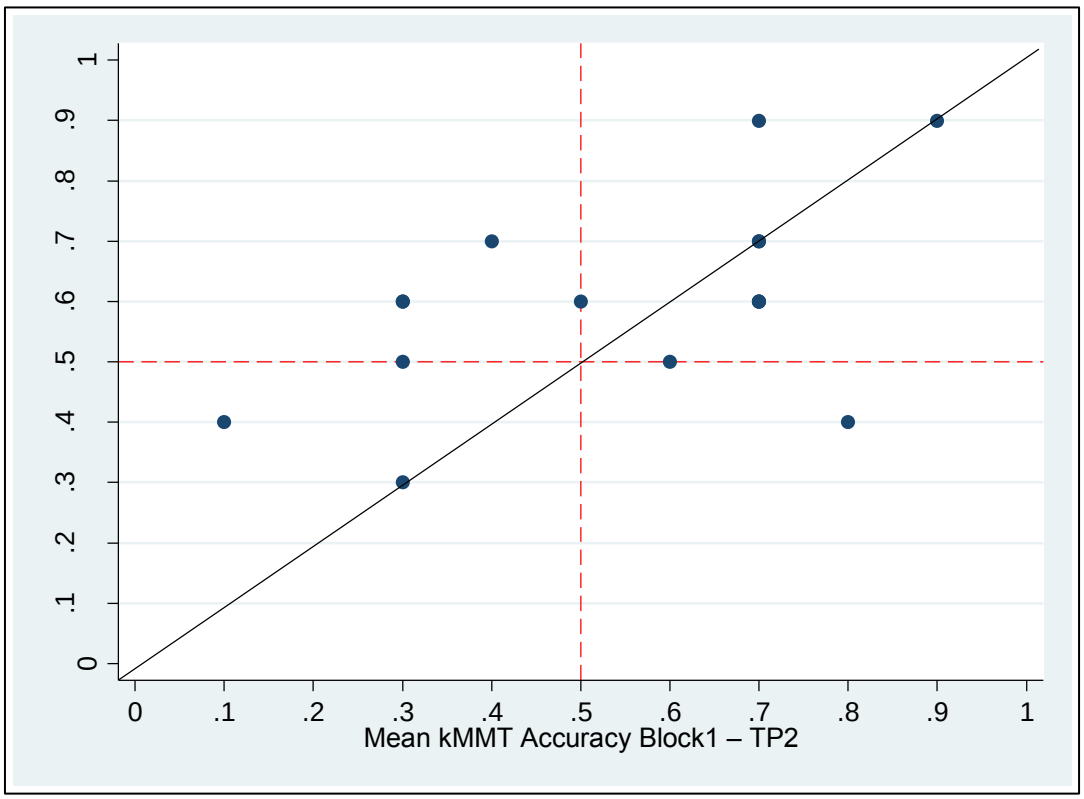
APPENDIX FIGURE B.5.1 (con't.)



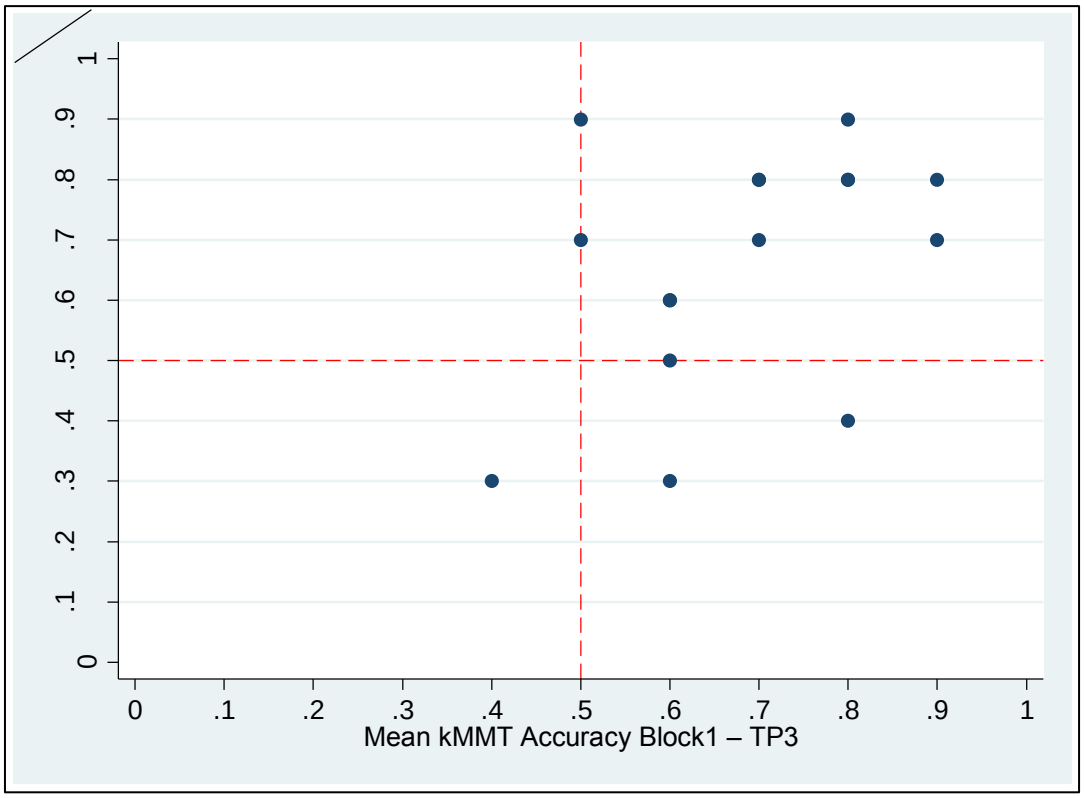


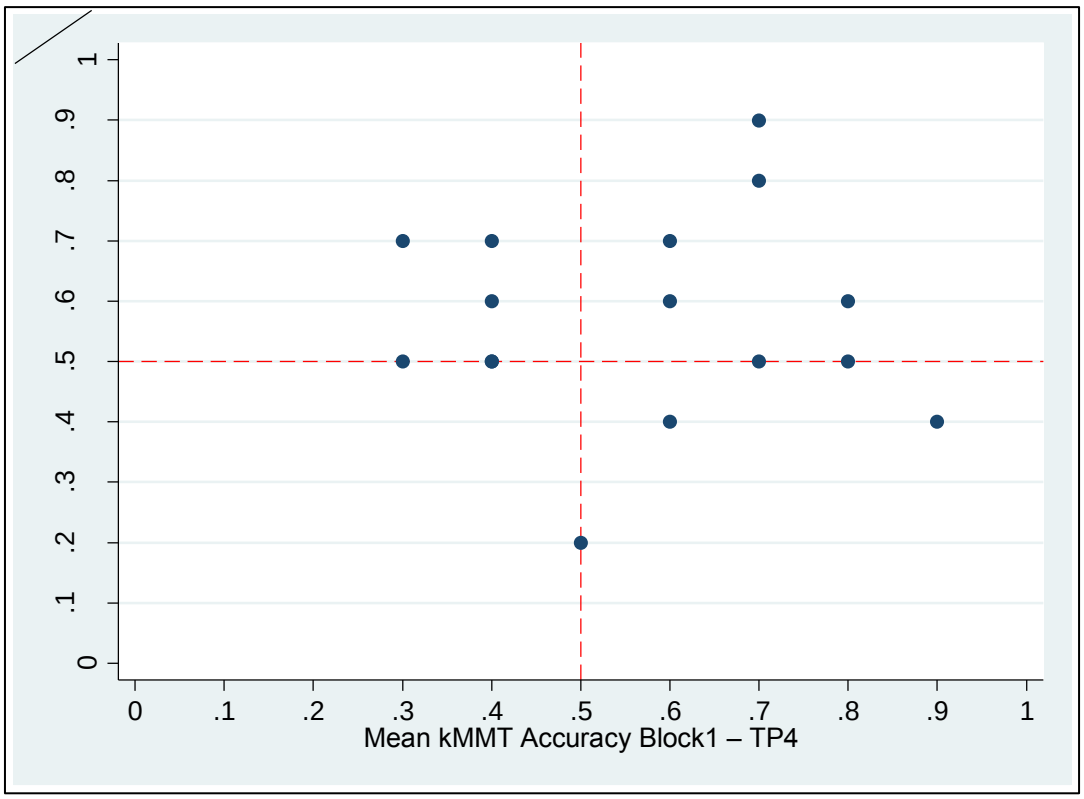
APPENDIX FIGURE B.5.2 - Repeatability scatterplots : Block 1 vs Block 2 – by TP (#1-6).



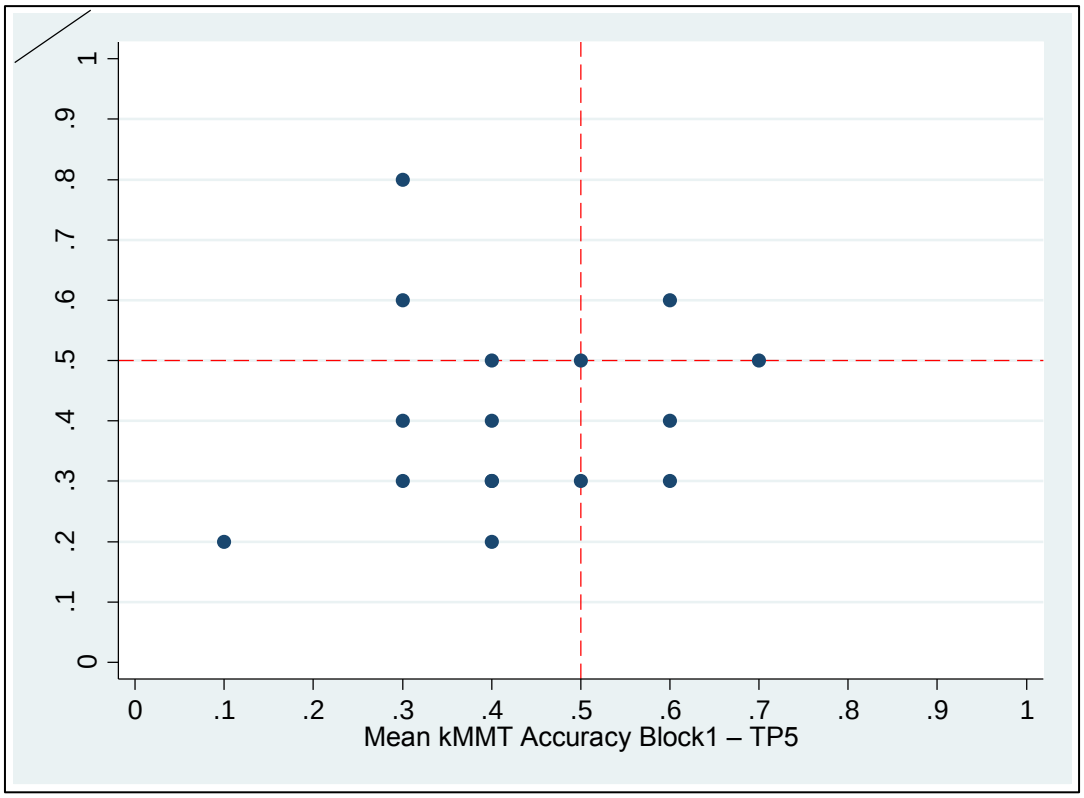


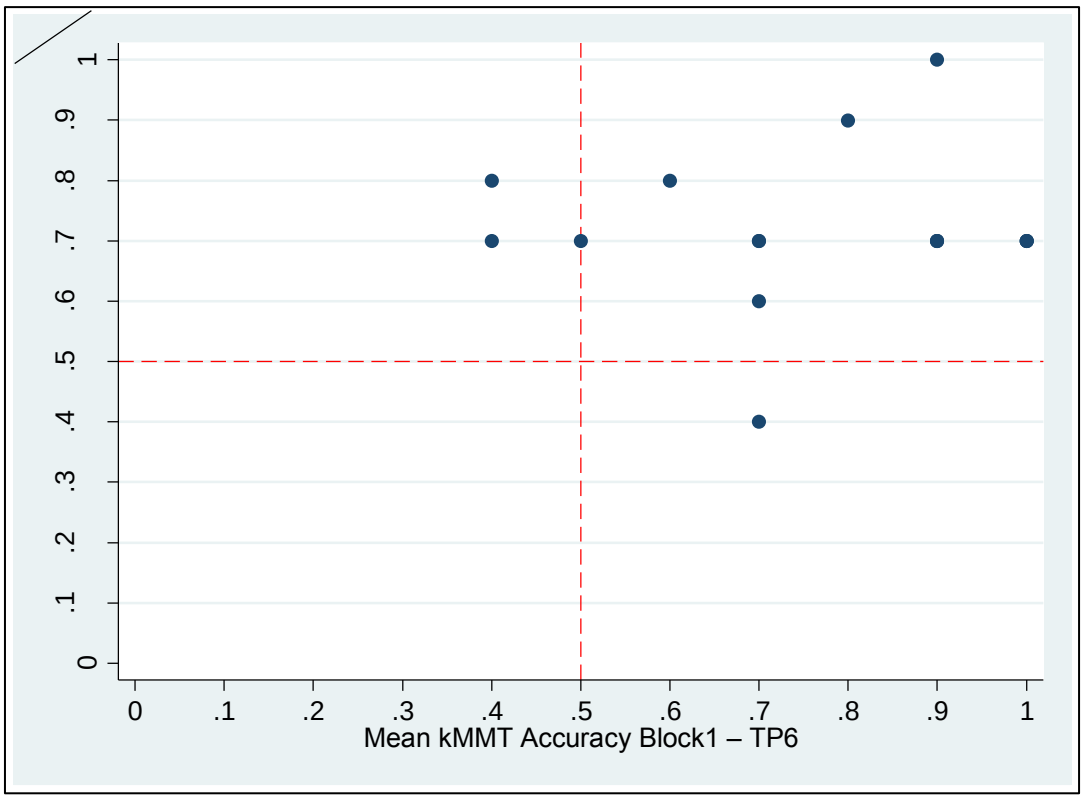
APPENDIX FIGURE B.5.2 (con't.)





APPENDIX FIGURE B.5.2 (con't.)





APPENDIX TABLE B.6.1 - kMMT & Intuition accuracies for all statements compared to True and False statements. Using all stimuli, for n=20 Pairs.

	ALL STATEMENTS			TRUE vs FALSE STATEMENTS					
				TRUE Statements			FALSE Statements		
	kMMT	Guessing	*p* -value	kMMT	Guessing	*p* -value	kMMT	Guessing	*p* -value
Mean	0.648[§]	0.526‡	**0.01***	0.675	0.574	0.08	0.620	0.483	**0.03***
95% CI	0.570 - 0.780	0.505 - 0.643		0.570 - 0.780	0.505 - 0.643		0.500 - 0.740	0.417 - 0.549	
Minimum	0.375	0.425		0.250	0.316		0.100	0.190	
Maximum	1.000	0.650		1.000	0.789		1.000	0.762	

kMMT, kinesiology-style Manual Muscle Testing; CI, Confidence Interval; *Significance reached

NOTE: kMMT accuracy for True vs. False: $p = 0.41$; Guessing accuracy for True vs. False Statements: $p = 0.11$; Using True Statements, kMMT accuracy compared to Chance: $p < 0.01$*; and using False Statements, kMMT accuracy compared to Chance: $p < 0.05$*.

APPENDIX TABLE B.6.2 - 2x2 Tables for kMMT for each Pair (n=20). Each Pair performed 40 kMMTs. Using (A) emotionally-arousing, and (B) affect-neutral stimuli.

Pair 1 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	1	1	2
	Strong (–)	8	7	15
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 1 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	1	1	2
	Strong (–)	10	11	21
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 2 - (A)		*Pair 1 - (B)*		
kMMT	Weak (+)	3	3	6
	Strong (–)	6	5	11
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 2 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	1	6	7
	Strong (–)	10	6	16
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 3 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	2	9
	Strong (–)	2	6	8
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 3 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	11	4	15
	Strong (–)	0	8	8
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 4 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	0	4
	Strong (–)	5	8	13
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 4 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	7	13
	Strong (–)	5	5	10
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 5 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	6	2	8
	Strong (–)	3	6	9
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 5 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	3	10
	Strong (–)	4	9	13
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

APPENDIX TABLE B.6.2 (cont'd.)

Pair 6 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	0	9
	Strong (–)	0	8	8
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 6 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	11	0	11
	Strong (–)	0	12	12
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 7 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	2	5
	Strong (–)	6	6	12
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 7 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	6	11
	Strong (–)	6	6	12
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 8 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	5	9
	Strong (–)	5	3	8
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 8 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	5	10
	Strong (–)	6	7	13
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 9 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	4	2	6
	Strong (–)	5	6	11
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 9 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	5	4	9
	Strong (–)	6	8	14
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 10 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	2	3	5
	Strong (–)	7	5	12
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 10 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	8	17
	Strong (–)	2	4	6
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

APPENDIX TABLE B.6.2 (cont'd.)

Pair 11 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	5	5	10
	Strong (–)	4	3	7
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 11 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	5	5	10
	Strong (–)	6	7	13
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 12 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	9	4	13
	Strong (–)	0	4	4
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 12 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	10	0	10
	Strong (–)	1	12	13
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 13 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	6	2	8
	Strong (–)	3	6	9
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 13 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	6	0	6
	Strong (–)	5	12	17
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 14 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	5	4	9
	Strong (–)	4	4	8
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 14 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	7	8	15
	Strong (–)	4	4	8
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 15 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	2	1	3
	Strong (–)	7	7	14
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 15 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	**Weak** (+)	7	8	15
	Strong (–)	4	4	8
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

APPENDIX TABLE B.6.2 (cont'd.)

Pair 16 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	7	3	10
	Strong (–)	2	5	7
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 16 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	10	1	11
	Strong (–)	1	11	12
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 17 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	1	10
	Strong (–)	0	7	7
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 17 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	10	1	11
	Strong (–)	1	11	12
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 18 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	3	5	8
	Strong (–)	6	3	9
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 18 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	8	9	17
	Strong (–)	3	3	6
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 19 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	9	6	15
	Strong (–)	0	2	2
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 19 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	8	9	17
	Strong (–)	3	3	6
	Totals	11	12	23

kMMT, kinesiology-style Manual Muscle Testing.

Pair 20 - (A)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	8	0	8
	Strong (–)	1	8	9
	Totals	9	8	17

kMMT, kinesiology-style Manual Muscle Testing.

Pair 20 - (B)		Actual Verity of Statement		Totals
		False (+)	True (–)	
kMMT	Weak (+)	10	0	10
	Strong (–)	1	12	13
	Totals	11	12	23

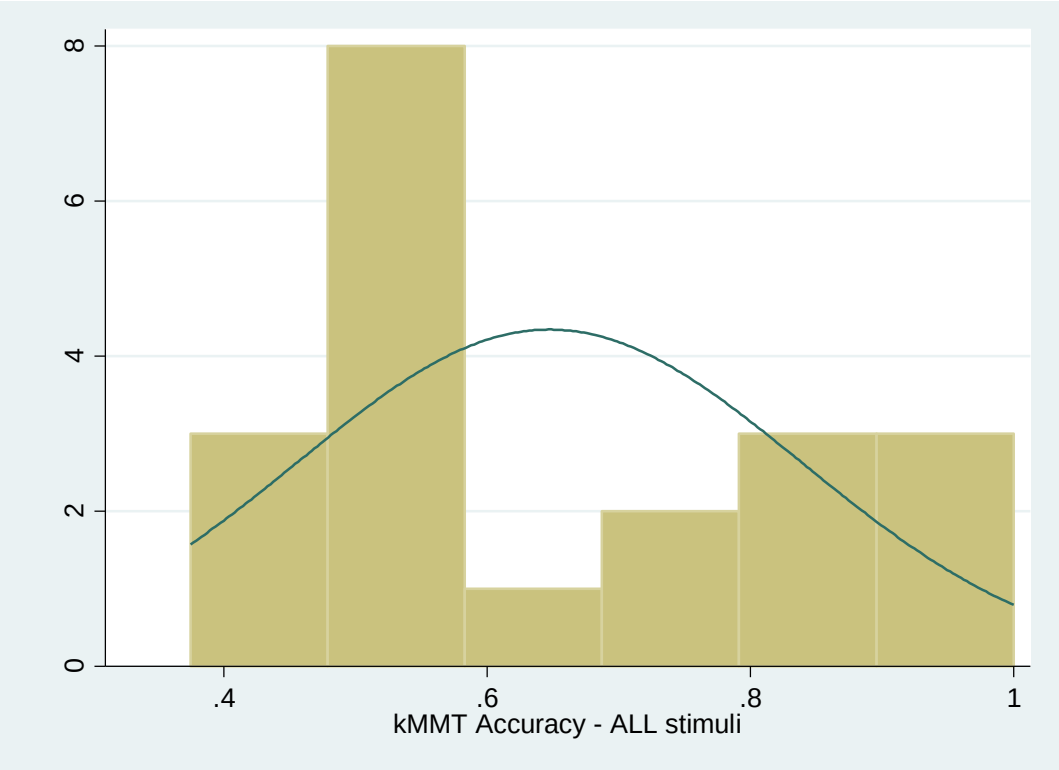
kMMT, kinesiology-style Manual Muscle Testing.

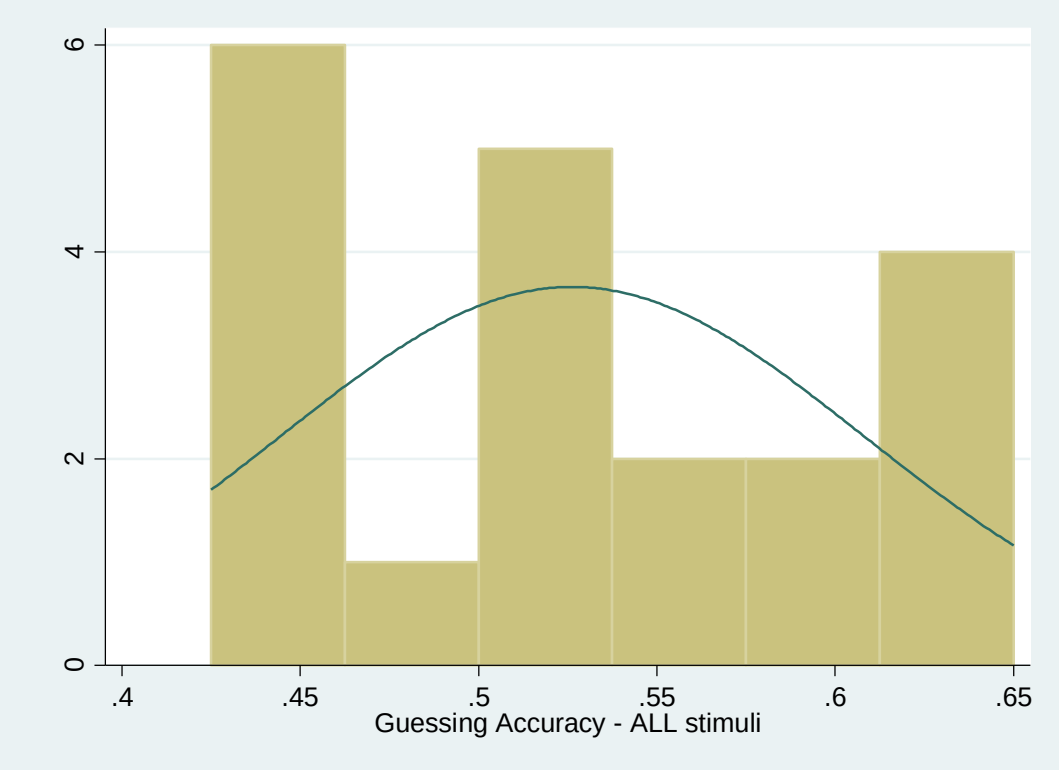
APPENDIX TABLE B.6.3 - Correlations amoung accuracy scores. kMMT & Guessing, Emotionally-arousing & Affect-Neutral Stimuli.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. kMMT Accuracy using Emotionally-Arousing Pictures	1.0000										
2. kMMT Accuracy using Affect-Neutral Pictures	0.7599 ***<0.01***	1.0000									
3. Guessing Accuracy using Emotionally-Arousing Pictures	-0.2222 *0.35*	0.0124 *0.96*	1.0000								
4. Guessing Accuracy using Affect-Neutral Pictures	0.3030 *0.19*	0.2399 *0.31*	0.1294 *0.59*	1.0000							
5. kMMT Accuracy using Emotionally-Arousing Spoken Words	0.9565 ***<0.01***	0.8385 ***<0.01***	-0.2030 *0.39*	0.2305 *0.33*	1.0000						
6. kMMT Accuracy using Affect-Neutral Spoken Words	0.7997 ***<0.01***	0.9746 ***<0.01***	0.0130 *0.96*	0.3044 *0.19*	0.8135 ***<0.01***	1.0000					
7. Guessing Accuracy using Emotionally-Arousing Spoken Words	0.0500 *0.83*	0.0679 *0.78*	0.5960 *0.01*	0.5766 *0.01*	0.0255 *0.92*	0.0922 *0.70*	1.0000				
8. Guessing Accuracy using Affect-Neutral Spoken Words	0.0969 *0.68*	0.2161 *0.36*	0.3938 *0.09*	0.6435 ***<0.01***	0.0569 *0.81*	0.2649 *0.26*	0.0991 *0.68*	1.0000			
9. kMMT Accuracy using Combined Emotionally-Arousing Simuli	0.9668 ***<0.01***	0.8061 ***<0.01***	-0.1876 *0.43*	0.1811 *0.44*	0.9713 ***<0.01***	0.8110 ***<0.01***	-0.0089 *0.97*	0.0515 *0.83*	1.0000		
10. kMMT Accuracy using Combined Affect-Neutral Stimuli	0.8124 ***<0.01***	0.9832 ***<0.01***	-0.0214 *0.93*	0.3296 *0.16*	0.8553 ***<0.01***	0.9832 ***<0.01***	0.1077 *0.65*	0.2459 *0.30*	0.8119 ***<0.01***	1.0000	
11. Guessing Accuracy using Combined Emotionally-Arousing Stimuli	-0.0419 *0.86*	0.2366 *0.32*	0.8763 ***<0.01***	0.3672 *0.11*	0.0049 *0.98*	0.2222 *0.35*	0.7703 ***<0.01***	0.3651 *0.11*	-0.0107 *0.96*	0.2087 *0.38*	1.0000
12. Guessing Accuracy using Combined Affect-Neutral Stimuli	0.2013 *0.39*	0.0290 *0.90*	0.0852 *0.72*	0.8880 ***<0.01***	0.0808 *0.73*	0.1219 *0.61*	0.3625 *0.12*	0.7116 ***<0.01***	0.0540 *0.82*	0.1353 *0.57*	0.1137 *0.63*

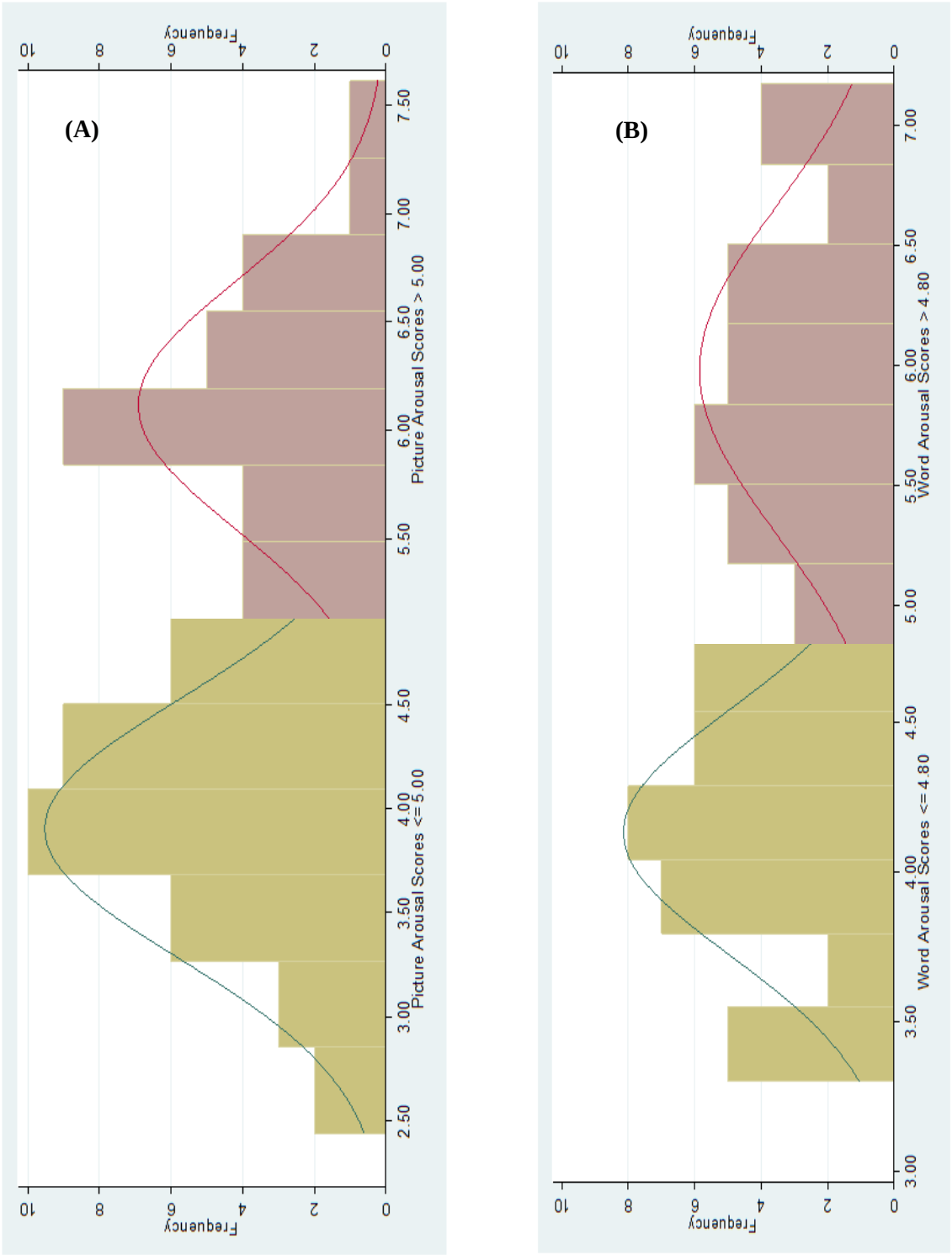
kMMT, kinesiology-style Manual Muscle Testing; gnificance reached.

APPENDIX FIGURE B.6.1 – Histograms for overall kMMT & Intuition accuracies.

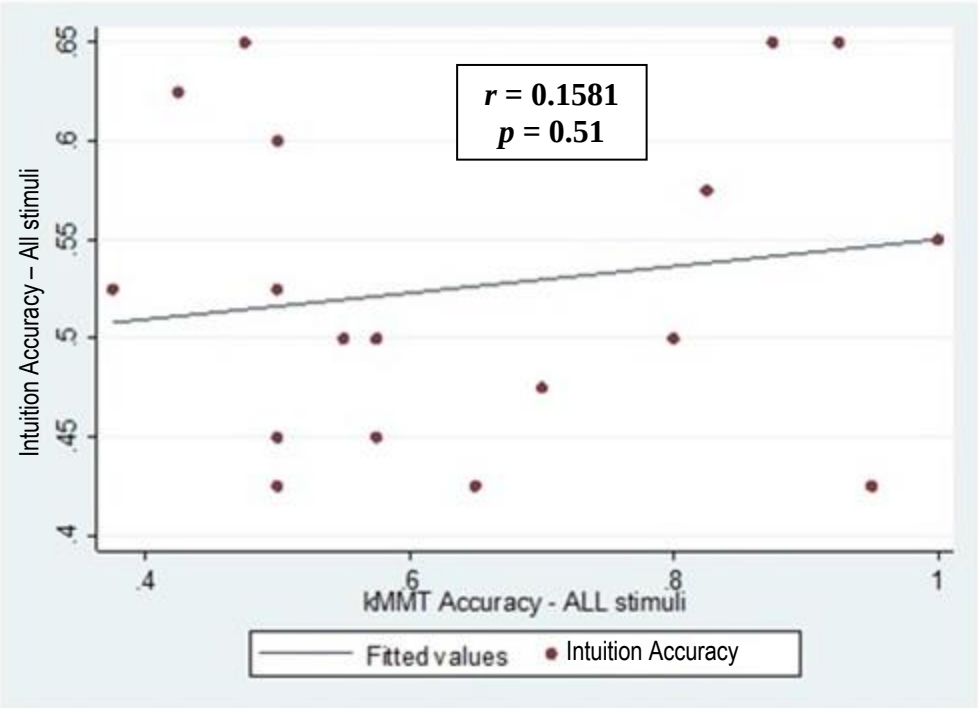




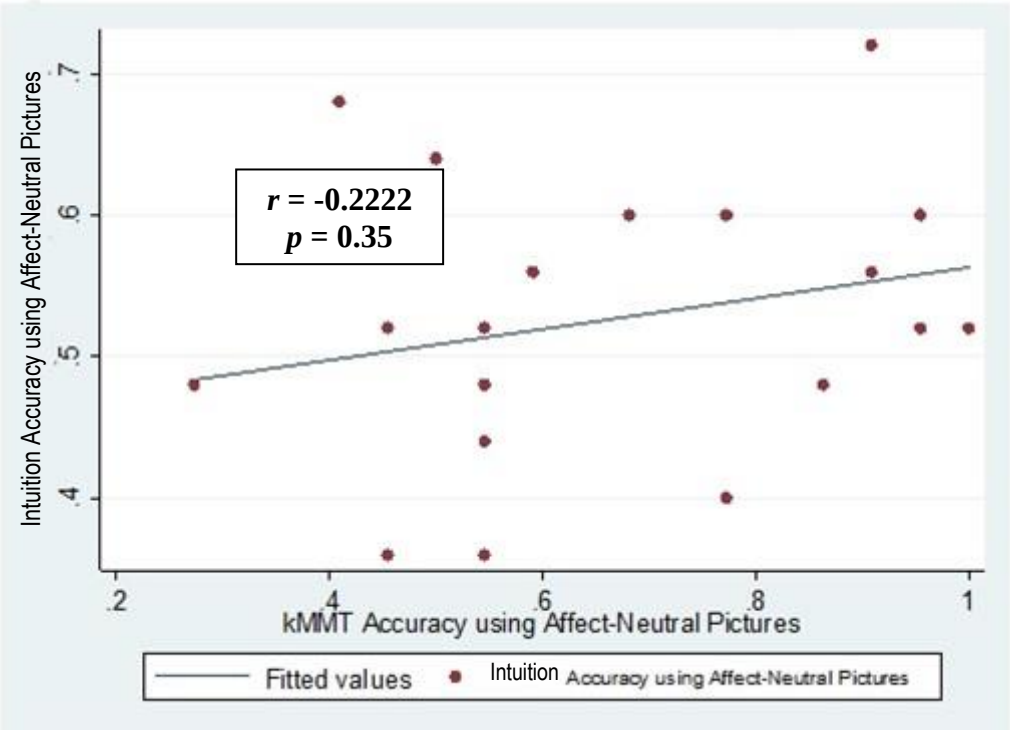
APPENDIX FIGURE B.6.2 – Histograms of the distribution of (A) picture and (B) word arousal levels – showing normal distributions.



APPENDIX FIGURE B.6.3 – Scatterplots. * Reached significance.

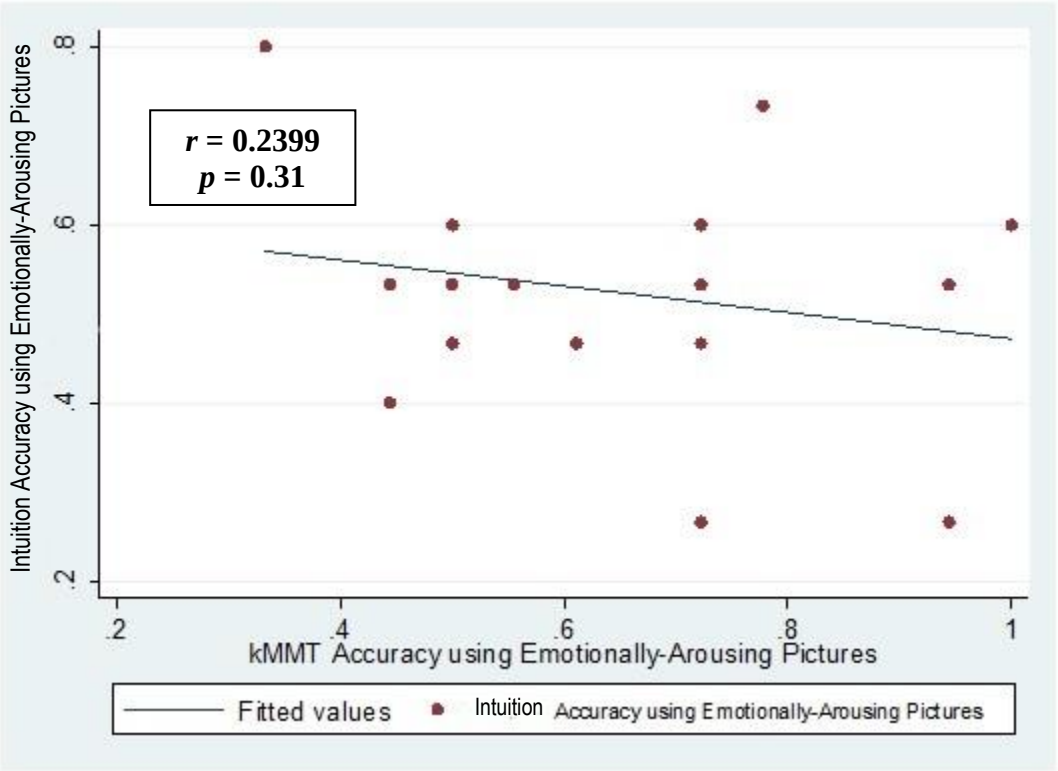


(A)

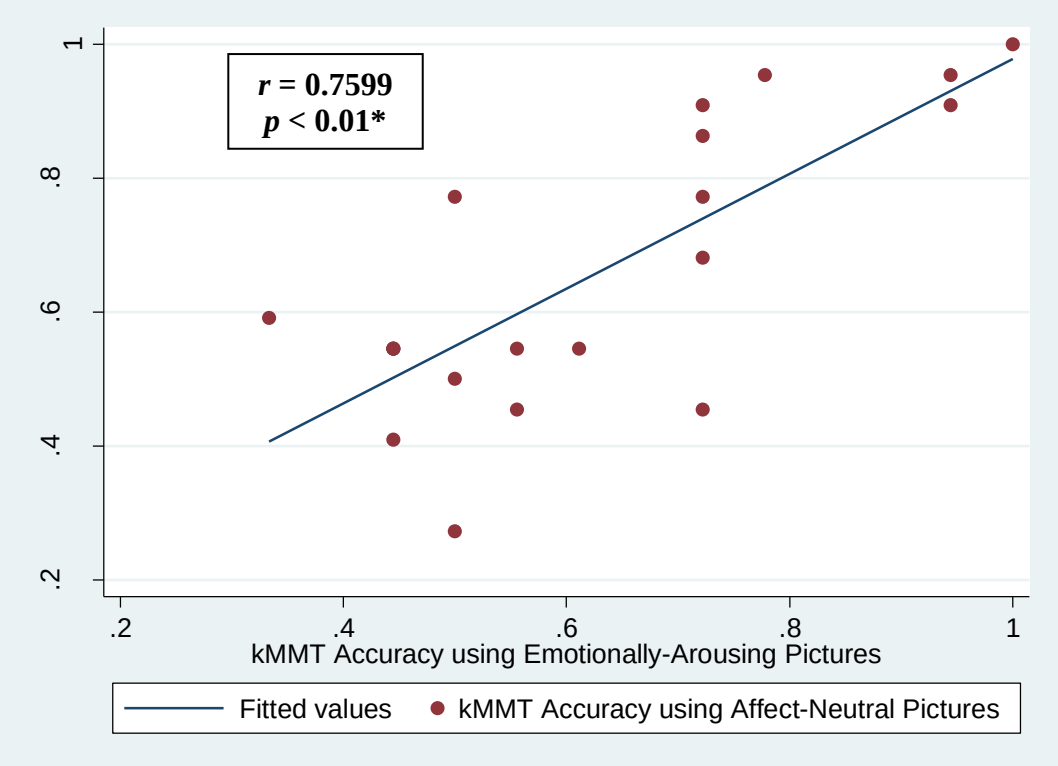


(B)

APPENDIX FIGURE B.6.3 (cont'd.)

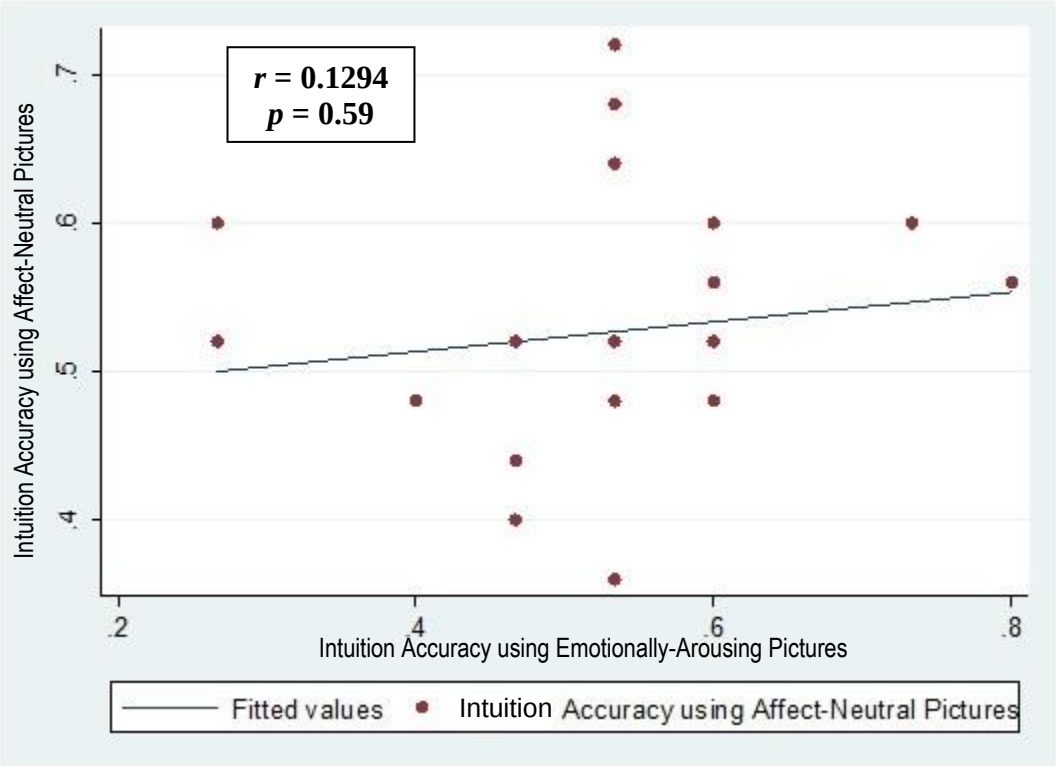


(C)

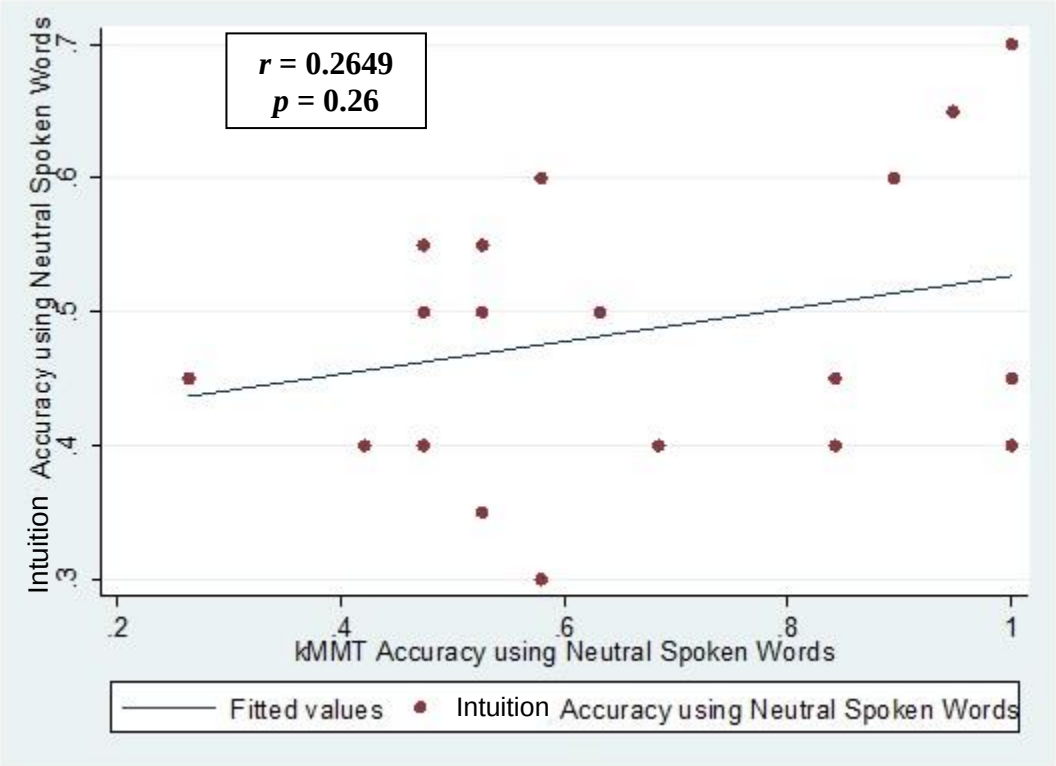


(D)

APPENDIX FIGURE B.6.3 (cont'd.)

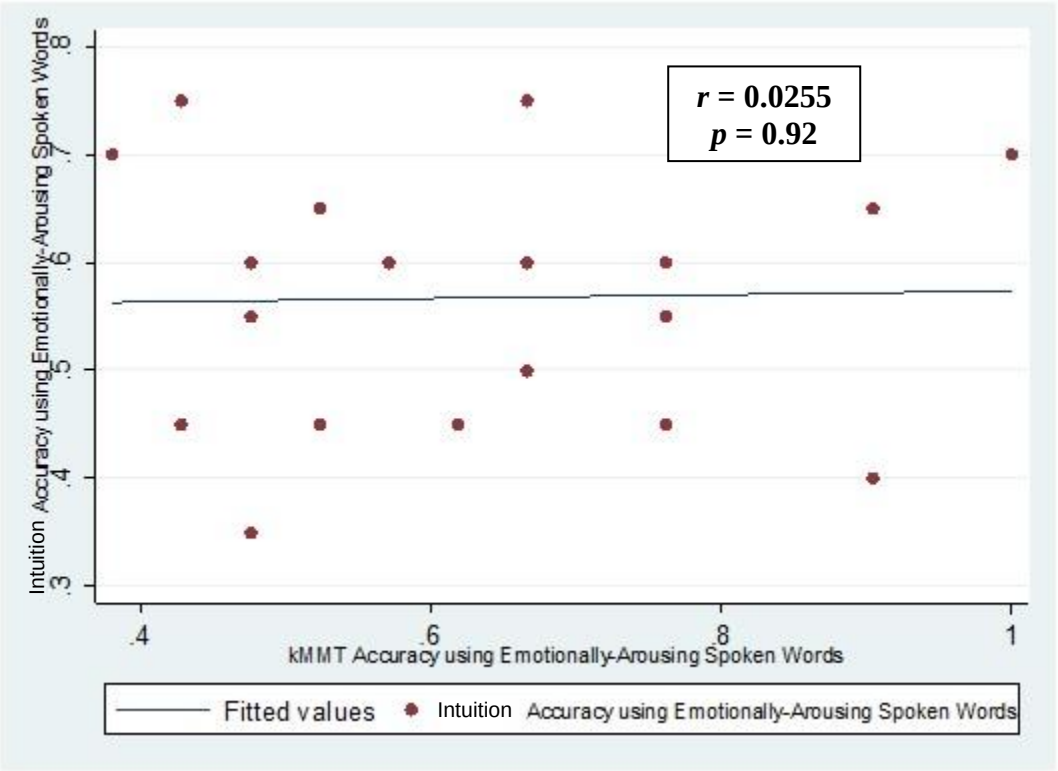


(E)

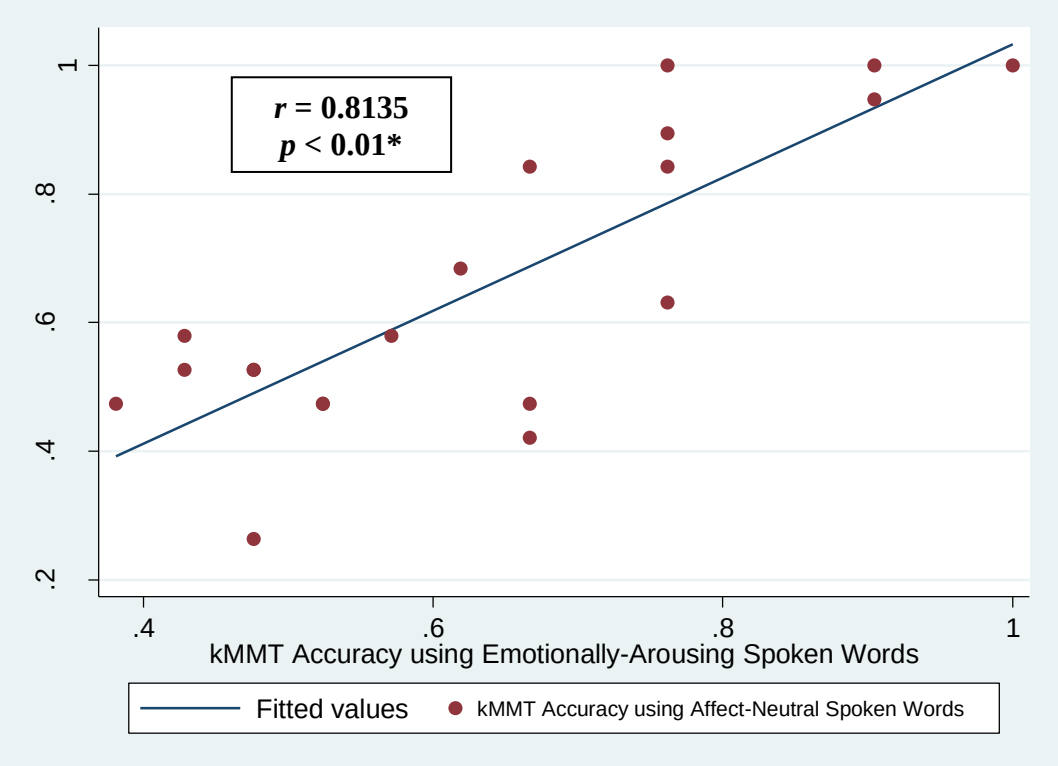


(F)

APPENDIX FIGURE B.6.3 (cont'd.)

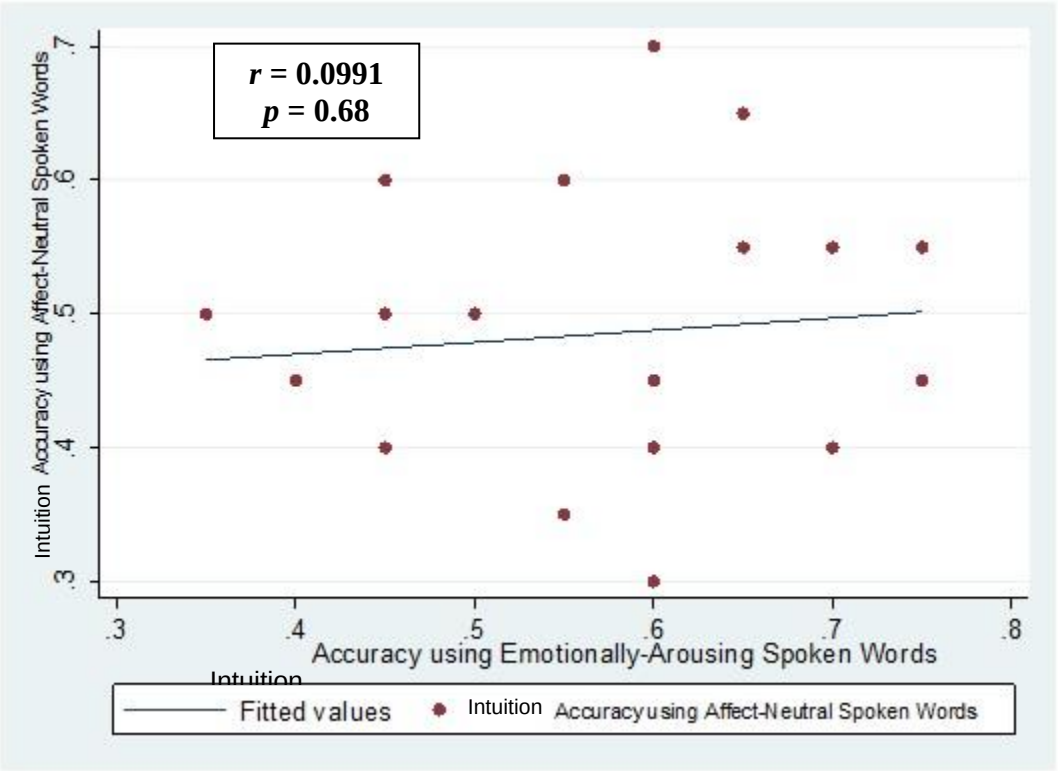


(G)

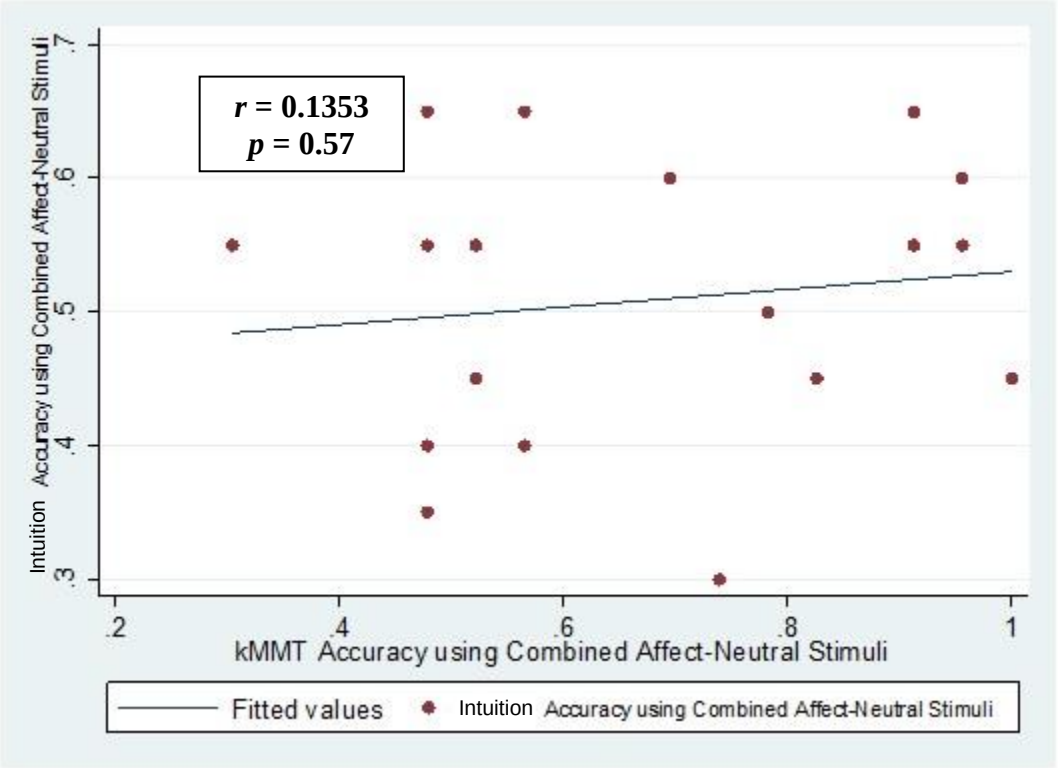


(H)

APPENDIX FIGURE B.6.3 (cont'd.)

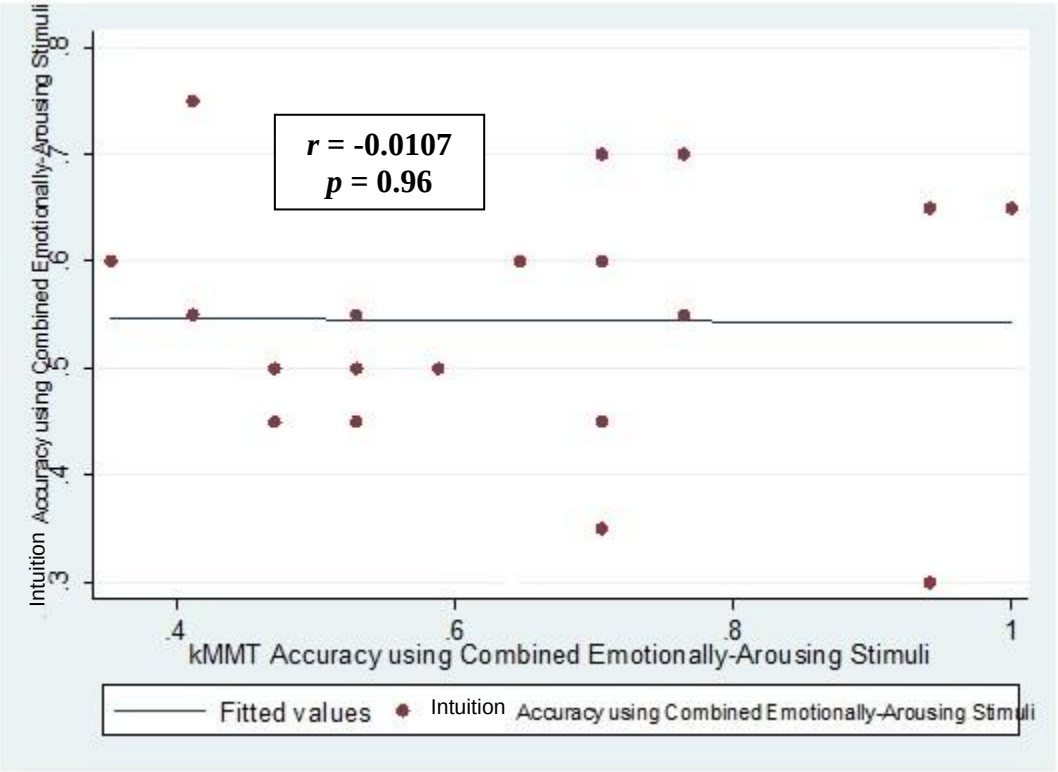


(I)

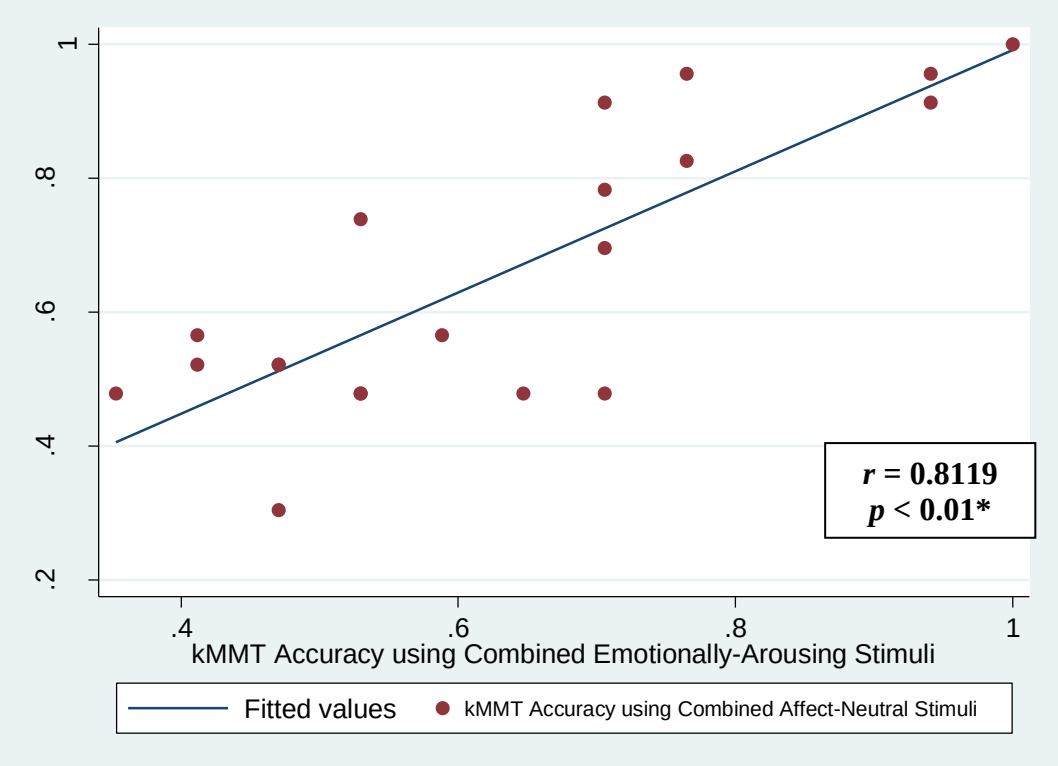


(J)

APPENDIX FIGURE B.6.3 (cont'd.)

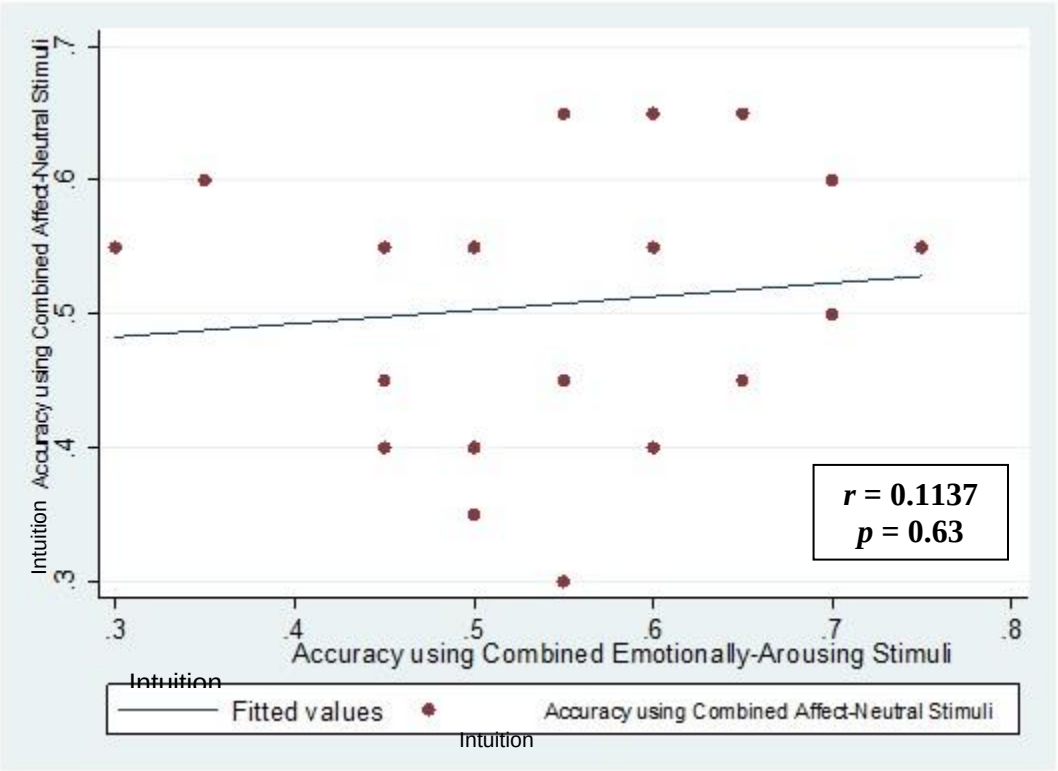


(K)

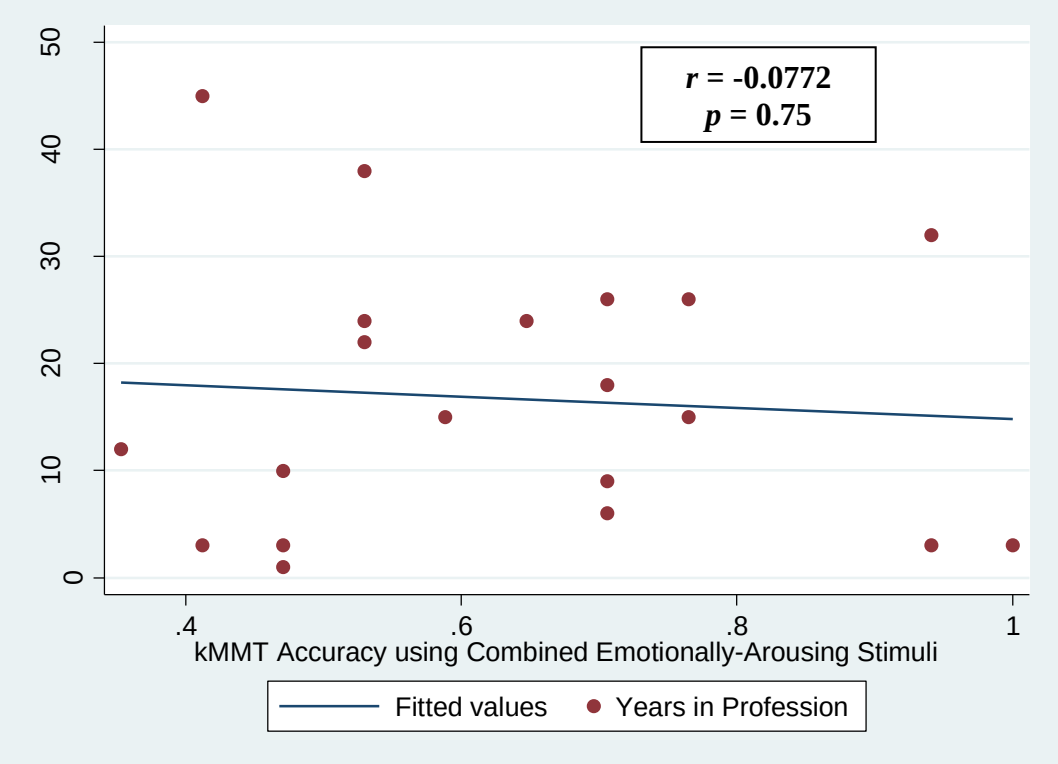


(L)

APPENDIX FIGURE B.6.3 (cont'd.)

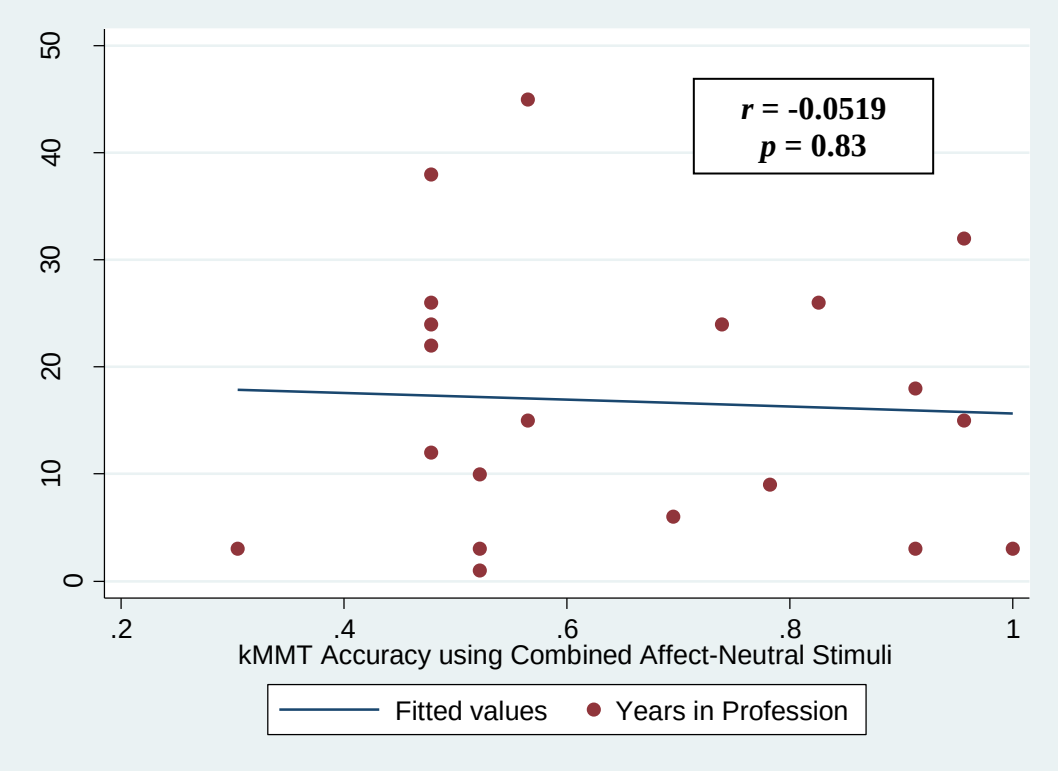


(M)

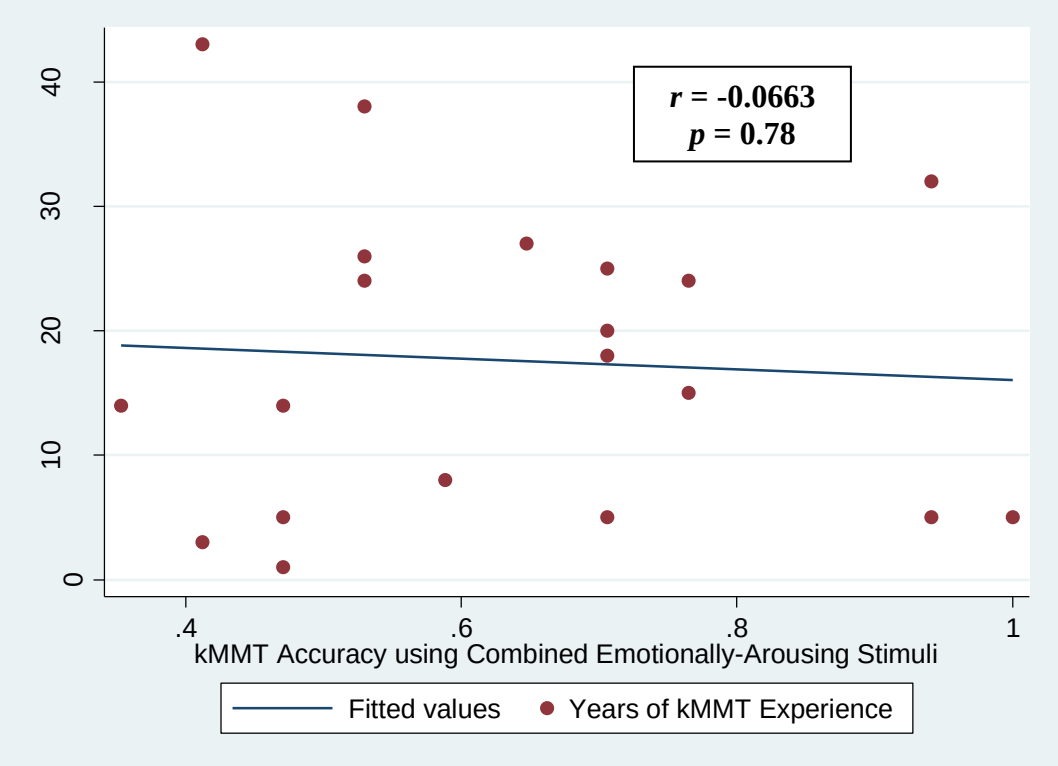


(N)

APPENDIX FIGURE B.6.3 (cont'd.)

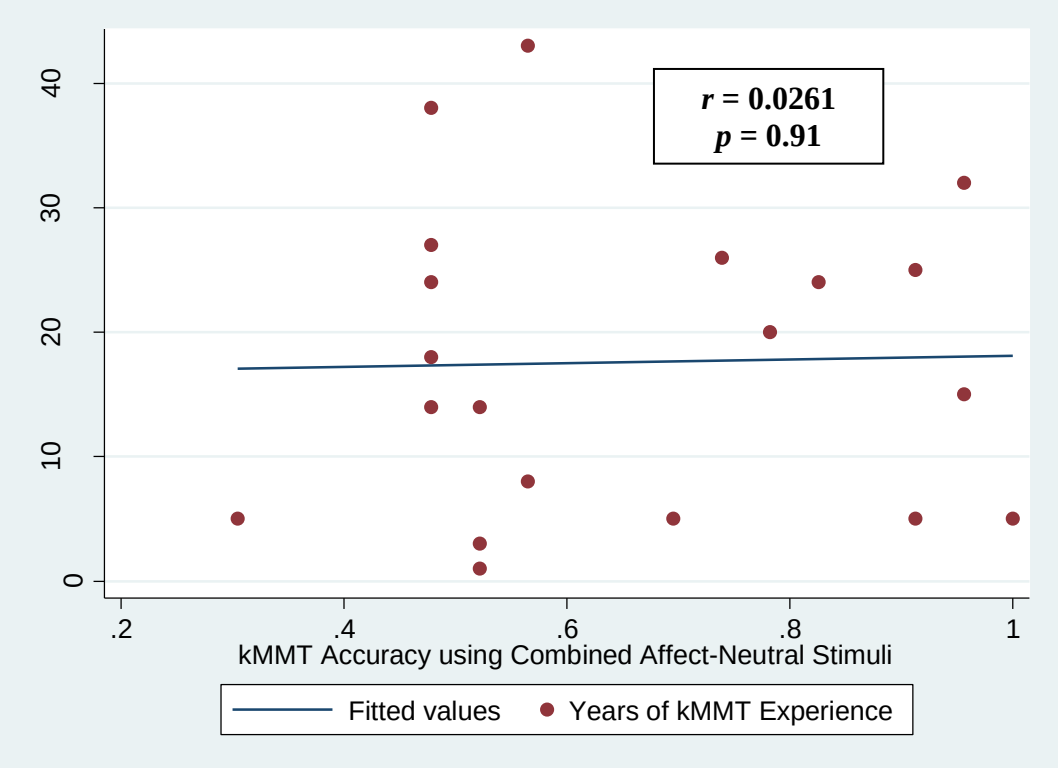


(O)

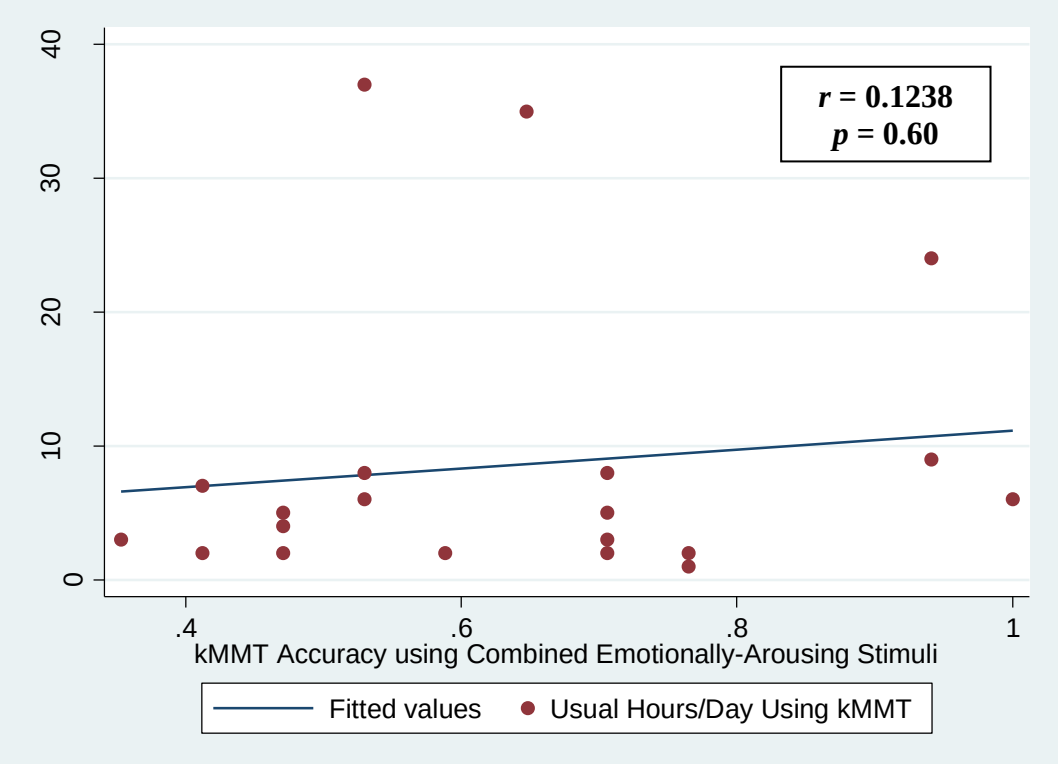


(P)

APPENDIX FIGURE B.6.3 (cont'd.)

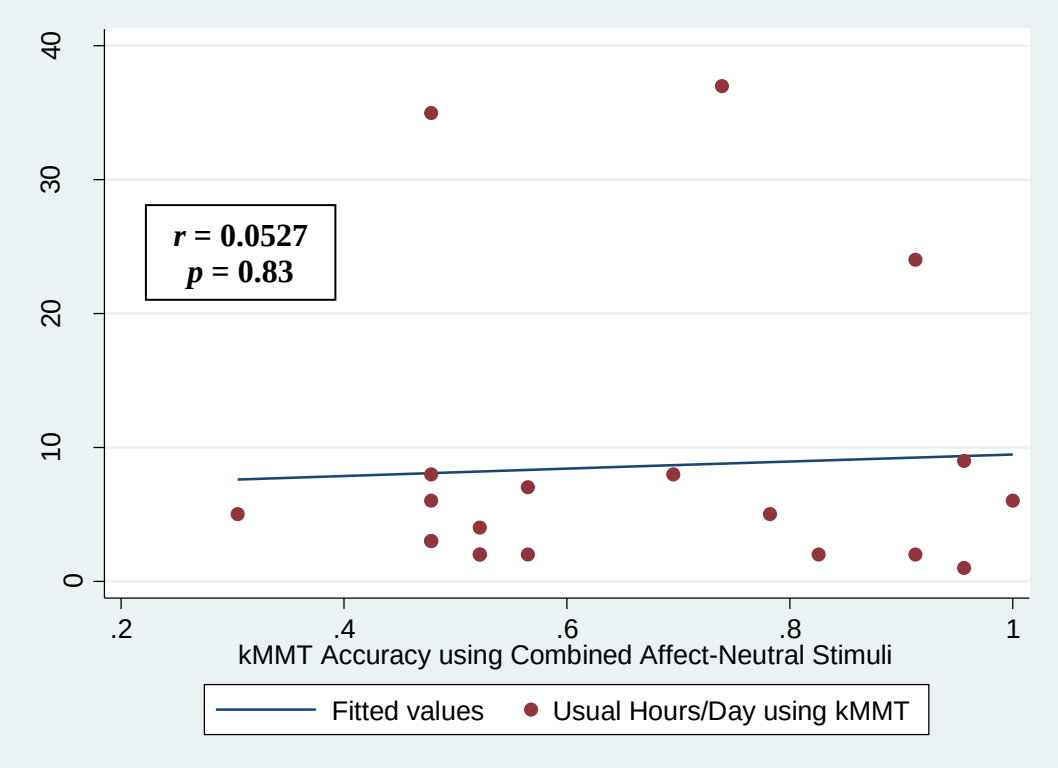


(Q)

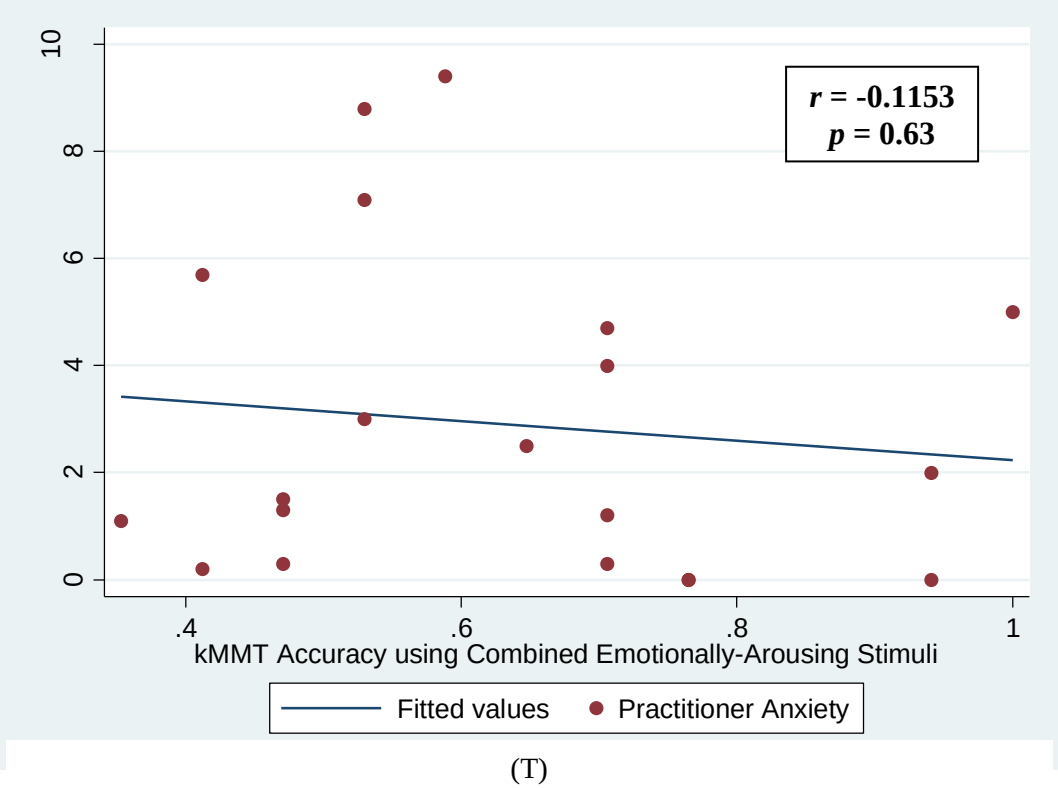


(R)

APPENDIX FIGURE B.6.3 (cont'd.)

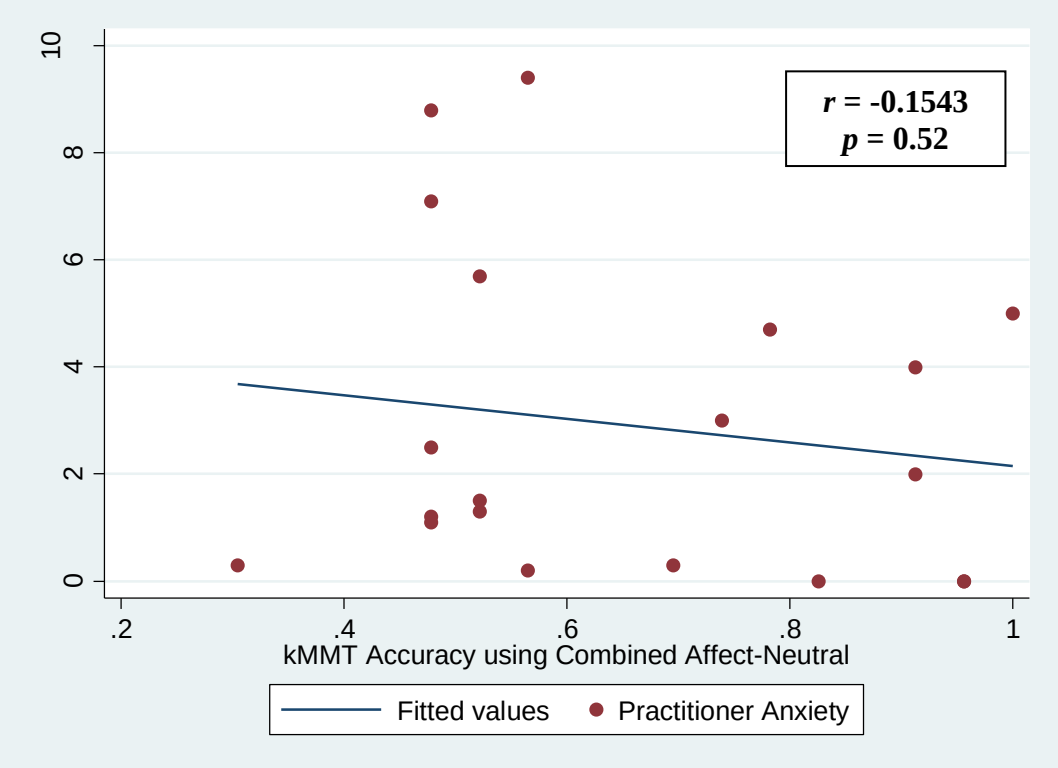


(S)



(T)

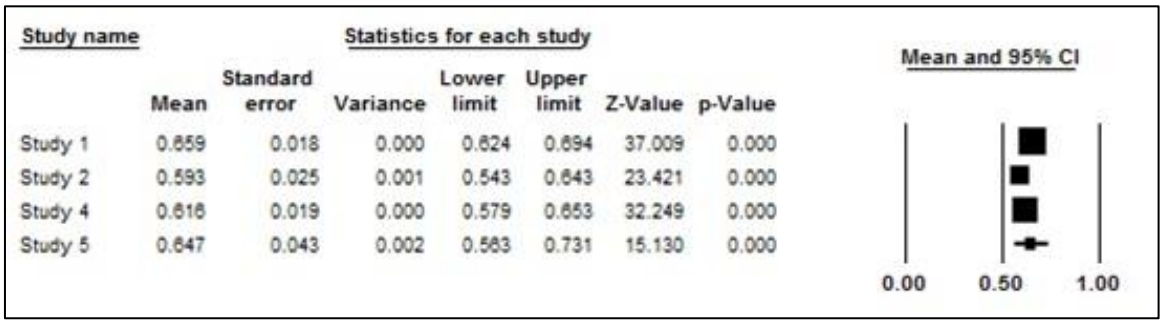
APPENDIX FIGURE B.6.3 (cont'd.)



(U)

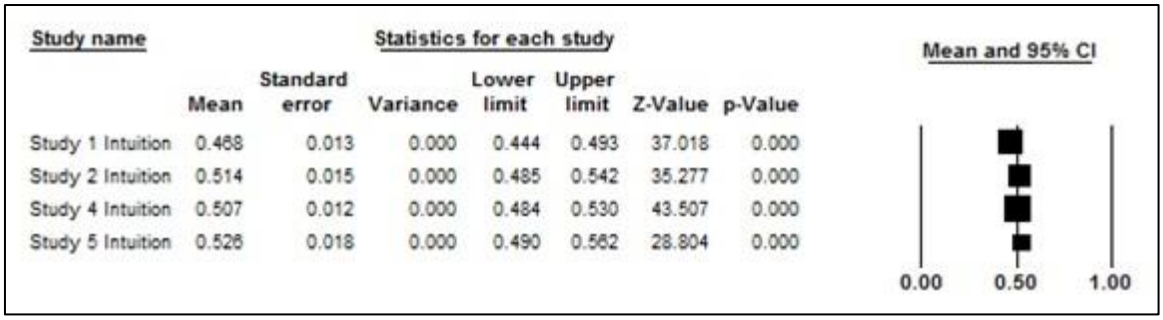
CHAPTER 7

APPENDIX FIGURE B.7.1 : Additional Forest Plots.



Study name	Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Study 1	0.659	0.018	0.000	0.624	0.694	37.009	0.000
Study 2	0.593	0.025	0.001	0.543	0.643	23.421	0.000
Study 4	0.616	0.019	0.000	0.579	0.653	32.249	0.000
Study 5	0.647	0.043	0.002	0.563	0.731	15.130	0.000

(A) Forest Plot for kMMT Accuracies.



Study name	Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Study 1 Intuition	0.468	0.013	0.000	0.444	0.493	37.018	0.000
Study 2 Intuition	0.514	0.015	0.000	0.485	0.542	35.277	0.000
Study 4 Intuition	0.507	0.012	0.000	0.484	0.530	43.507	0.000
Study 5 Intuition	0.526	0.018	0.000	0.490	0.562	28.804	0.000

(B) Forest Plot for Intuition Accuracies.

APPENDIX C

The Prevalence of Use of kMMT

"There may be fairies at the bottom of the garden. There is no evidence for it, but you can't prove that there aren't any, so shouldn't we be agnostic with respect to fairies?"

Richard Dawkins

APPENDIX C : THE PREVALENCE OF USE OF KMMT

ABSTRACT

Research Objectives: To investigate the prevalence of use of kinesiology-style manual muscle testing (kMMT).

Methods: First, a search of internet databases, textbooks and expert opinion were used to compile a list of known kMMT technique systems. Then, direct contact was attempted via email and telephone to representatives of each individual kMMT technique system. Once contacted, the representative was asked to provide a conservative estimate of the number of people trained in their form of kMMT. For those organisations unable to provide an estimate, additional expert opinion was sought to approximate the numbers trained.

Results: Seventy-nine kMMT technique systems were identified, 46 of which provided the requested estimate and 33 did not (for various reasons). From the information collected, kMMT was estimated to be used by over 1 million people worldwide.

Summary: With over 1 million people trained worldwide, the widespread use of kMMT merits further consideration, and proper exploration of its usefulness in clinical settings. This estimation might be amplified due to the possibility of redundancies or attrition. Likewise, it might be low due to misclassification or too narrow search methods.

Keywords: prevalence; education; kinesiology; muscle weakness; muscle contraction.

Introduction

Kinesiology-style manual muscle testing (kMMT) is used by a variety of healthcare professionals to gain more information about patients. Different from both manual muscle testing (MMT) and the MMT used in Applied Kinesiology (AK-MMT) since kMMT usually only uses one "indicator muscle" to detect a specified target condition. These target conditions can range from physiological dysfunction (e.g. organ or system dysfunction) to meridian imbalance to a patient's level of stress, as well as to the integrity of the neuromuscular system.

It has been reported that AK-MMT is used by approximately 40% of American chiropractors.[12, 13, 218] However it is uncertain how many people use kMMT. Therefore, the initial purpose of this study was to estimate the number of people that use kMMT.

This aim seemed straight forward at first; however, when fully explored, it became quite complex. First of all, more than just chiropractors use kMMT in practice. For example, health care practitioners such as some psychologists, acupuncturists, naturopaths and massage therapists use kMMT, but not all of these types of practitioners do. Also, more than just health care professionals use kMMT, for example, some educators, coaches and parents. But not all of these do either. Furthermore, it is widely known that there are possibly hundreds of different kMMT technique systems and various professional kMMT organisations, the memberships of which may overlap. Finally, since kMMT is not widely accepted and perhaps even thought of as quackery, it is also possible that people that use kMMT do not want to be known to be using it (i.e. "closet" practitioners), and so may not appear on any formal registry.

Therefore, it quickly became clear that the prevalence of use of kMMT would be challenging to determine exactly. Consequently, the aim of the study then changed to estimating the number of people *trained* to use kMMT. From this information, one can then make an informed inference as to the prevalence of use of kMMT.

Methods

The first step taken to estimate the number of people trained to use kMMT was to create a list of all organisations that offer or have offered training in kMMT or a system that uses kMMT. Electronic searches were conducted using Google and MEDLINE (September 2009). No time or language restrictions were used. Search terms were ["muscle test*" OR "kinesiology"]. In addition, books on chiropractic techniques were consulted,[219, 220] and experts in the field were contacted via telephone, email and social media.

After the list of kMMT techniques / educators was compiled, contact was attempted by both email and telephone, and two specific questions were asked: (1) *"Do you use kinesiology or muscle testing in (their technique)?"* and if yes, then: (2) *"In your best conservative estimate, how many people have been trained in (their technique)?"* The technique system was included if they responded "Yes" to the first question. Data was collected between May 2008 and November 2009.

For completeness, a list of kMMT professional associations was also compiled, but no membership information (e.g. size) was sought.

Results

Seventy-nine technique systems were identified to use some form of kMMT. Despite attempts being made to contact all organisations, only 46 provided estimations of the number

of people trained in their technique. See Appendix Table C.1. Of the 33 organisations that did not provide estimates, some were not contactable, some did not respond to contact, some stated that they could not provide an estimate, and some refused to answer. Instead, experienced practitioners in these techniques were consulted to provide best guess estimates of the number of people trained in their respective technique systems, and these numbers are also listed in Appendix Table C.1.

From the information provided by the 46 contactable technique systems, it can be inferred that over 900,000 people were trained to use kMMT. In addition, it was estimated that another 110,000 people were trained in the use of kMMT in the 33 technique systems which did not provide information. Therefore, it was estimated that over 1 million people were trained to use kMMT. In addition, 65 professional associations or schools of kMMT were identified globally. For completeness, a list can be found in Appendix Table C.2.

FIGURE C.1 - Estimated number of practitioners trained in various Muscle Testing Techniques. The estimates provided can be considered conservative estimates, meaning *at least* thess numbers of people trained. The information in the top part of the table was provided by respective organisations via personal email, telephone or from the respective website. In the bottom part of the table, no information was provided by the respective organisation, but was estimated by experts in these fields.

		Estimated # Trained	Technique System Name	Anacronym
Technique representative provided information	1	150,000	Touch for Health	TFH
	2	110,000	Applied Kinesiology	AK
	3	100,000	Sacro-Occipital Technique	SOT
	4	80,000	Thought Field Therapy	TFT
	5	65,000	Contact Reflex Analysis	CRA
	6	65,000	PSYCH-K	
	7	60,000	Total Body Modification	TBM
	8	45,000	Yuen Method	
	9	35,000	Educational Kinesiology / Brain Gym	Edu-K
	10	30,000	Bio-Energetic Synchronization Technique	BEST
	11	30,000	Nambudripad's Allergy Elimination Technique	NAET
	12	25,000	RESET TMJ	
	13	20,000	Health Kinesiology	HK
	14	15,000	Advanced Energy Psychology™	ARP
	15	12,000	Applied Physiology	AP
	16	12,000	Neuroenergetic Psychology	NEP
	17	10,000	Neural Organization Technique	NOT
	18	6,000	Neuro Emotional Technique	NET
	19	3,500	Intuitive Kinesiology	
	20	3,000	Kinergetics	
	21	3,000	Metabolics - Functional Biochemistry	
	22	2,800	Chirodontics	
	23	2,500	Human Ecology Balancing Science	HEBS
	24	2,500	Manual Kinesiology	MAK
	25	2,500	Neuro Impulse Protocol	NIP
	26	2,200	Psychosomatic Energetics	PSE
	27	2,000	Chiro Plus Kinesiology	CPK
	28	2,000	Cranial Release Technique	CRT
	29	2,000	Neuro Energetic Kinesiology	NEK
	30	1,500	Dobson Muscle Testing Technique	DMT
	31	1,500	Matrix Response Testing	MRT
	32	1,500	One Brain (aka 3-in-1 Concepts)	
	33	1,200	Integrative Kinesiology	IK
	34	1,000	Foundation Clinical Kinesiology	
	35	1,000	Neuro-Modulation Technique	NMT
	36	1,000	Zahnärztliche PhysioEnergetik" (Dental Physioenergetics)	ZÄPE
	37	700	Aromatic Kinesiology	
	38	500	(The) Vickery Method	TVM
	39	500	Integrated Biodynamics	IBD
	40	500	Systematic Kinesiology	
	41	250	Synergistic Kinesiology	
	42	150	Allergy Pathway	
	43	120	Extreme Kinesiology	XK
	44	120	HoloDynamic Kinesiology	HDK
	45	60	Kinesiologie nach Gauer	
	46	50	Chirokinetic Therapy	CKT
		909,650	*Subtotal*	
Technique representative did not provide information*	47	20,000	Emotional Code	
	48	15,000	Clinical Kinesiology	CK
	49	10,000	BodyTalk	
	50	10,000	NeuroLink	
	51	5,000	Be Set Free Fast	BSFF
	52	5,000	Learning Enhancement Advanced Program	LEAP
	53	5,000	Nutritional Response Testing	NRT
	54	5,000	Wholistic Kinesiology	
	55	3,000	Power vs. Force system	
	56	3,000	Professional Kinesiology Practice	PKP
	57	3,000	Wellness Kinesiology	
	58	2,000	Biokinesiology	BK
	59	2,000	Integrative Manual Therapy	IMT
	60	2,000	NeuroLinguistic Kinesiology	NLK
	61	2,000	Progressive Kinesiolgy	
	62	1,000	Advanced Allergy Therapeutics	
	63	1,000	Applied Psychoneurobiology	APN
	64	1,000	Autonomic Response Testing	ART
	65	1,000	Balance Kinesiology	
	66	1,000	Brain Integration Technique	BIT
	67	1,000	Cyberkinetics - Cybernetic Kinesiology	
	68	1,000	Energetic Kinesiology	
	69	1,000	Energy Consciousness Therapy	ECM
	70	1,000	Energy Diagnostic & Treatment Methods / Advanced Energy Psychology	EDxTM
	71	1,000	EnergyField Kinesiology	
	72	1,000	Negative Affect Erasing Method	NAEM
	73	1,000	Neural Systems Kinesiology	
	74	1,000	Neuro Organization Work	NOW
	75	1,000	Neurobiology / Neural Therapy / Psycho-Kinesiology	
	76	1,000	Physioenergetik	
	77	1,000	Riddler Reflex Technique	
	78	1,000	Stress Indicator Point System	
	79	1,000	Transformational Kinesiology	TK
		110,000	*Subtotal*	
		1,019,650	TOTAL	

*Reasons for not providing information include: (1) Not be contactable, (2) Not responding to contact, (3) Not being able to provide estimate, and (4) refusing to provide estimate.

NOTE: To provide updated information or make corrections, please email: dranne@drannejensen.com.

APPENDIX TABLE C.2 - Kinesiology Organisations and Schools

	Professional Association or School	Country	Website
1.	Association of Specialised Kinesiologists - KwaZulu-Natal	South Africa	www.kinesiology.co.za
2.	Association of Specialised Kinesiologists South Africa	South Africa	www.kinesiologysa.co.za
3.	Australasian College of Kinsesiology Mastery	Australia	www.kinesiologymastery.com
4.	Australian Kinesiology Association	Australia	http://www.kinesiology.org.au/
5.	Berner Institut für Kinesiologie / Institut Bernois de Kinésiologie	Switzerland	www.bik.ch
6.	Biokinesiolog Skolen	Denmark	www.kbhkinesiologiskole.dk
7.	College of Complementary Medicine - Australia	Australia	www.complementary.com.au
8.	Dansk Pædagogisk Kinesiologiskole	Denmark	www.kinesiologi-uddannelse.dk
9.	Danske Kinesiologer	Denmark	www.kinesiologi.dk/
10.	Den Norske Kinesiologi Forening	Norway	www.dnkf.org
11.	Den Norske Kinesiologi Skolen	Norway	
12.	Deutsche Gesellschaft für Angewandte Kinesiologie	Germany	www.dgak.de
13.	Deutschen Ärztegesellschaft für Applied Kinesiology	Germany	www.daegak.de
14.	Energy Kinesiology Association USA	USA	www.ask-us.org
15.	Fédération Belge de Kinésiologie	Belgium	www.kinesiologybelgium.org
16.	Health Umbrella Kinesiology Practitioners	UK	www.healthumbrella.co.uk
17.	I.K.S.E.N.	Italy	www.iksen.it
18.	Institut Belge de Kinesiologie	Belgium	www.ibk.be
19.	Institut für Angewandte Kinesiologie	Germany	www.iak-freiburg.de
20.	Institut für Kinesiologie Zürich	Switzerland	www.kinesiologie.edu
21.	Integrated Practitioner Training	UK	www.integrated-kinesiology.co.uk
22.	International Association of Specialized Kinesiology	Worldwide	www.iask.org
23.	International College of Applied Kinesiology	Worldwide	www.icak.com
24.	International College of Applied Kinesiology - Australasia	Australia	www.icak-australasia.com
25.	International College of Applied Kinesiology - Austria	Austria	www.icak-d.de
26.	International College of Applied Kinesiology - Benelux	Belgium, Netherlands, Luxembourg	www.icakbenelux.com
27.	International College of Applied Kinesiology - Brasil	Brazil	www.icak.com.br
28.	International College of Applied Kinesiology - Canada	Canada	www.icakcanada.com
29.	International College of Applied Kinesiology - Germany	Germany	www.icak-d.de
30.	International College of Applied Kinesiology - Korea	Korea	www.ak.or.kr
31.	International College of Applied Kinesiology - UK	UK	www.icak.co.uk
32.	International College of Applied Kinesiology - USA	USA	www.icakusa.com
33.	International Institute of Kinesiology	Australia	www.iikinesiology.com
34.	International Kinesiology College	Australia / Worldwide	www.ikc-info.org; www.tfhka.org
35.	International Medical Society for Applied Kinesiology	Austria	www.imak.co.at
36.	International NeuroKinesiology Institute	Poland	
37.	Internationale Kinesiologie Akademie	Germany	
38.	Japan Touch for Health Association	Japan	www.touch4health.ne.jp
39.	KinAP	Switzerland	www.kinap-verband.ch
40.	Kinesiologiforeningen	Denmark	www.kinesiologiforeningen.dk
41.	Kinesiology College of Canada	Canada	www.kinesiologycollegeofcanada.com
42.	Kinesiology College of Ireland	Ireland	http://www.kinesiologycollege.com/
43.	Kinesiology College of Ireland	Ireland	http://www.kinesiologyireland.com/
44.	Kinesiology Federation of UK	UK	www.kinesiologyfederation.org
45.	Kinesiology Institute	USA	www.kinesiologyinstitute.com
46.	KineSuisse	Switzerland	www.kinesuisse.ch
47.	Klinghardt Academy - Germany	Germany	http://www.ink.ag/
48.	Klinghardt Academy - UK	UK	http://www.klinghardtacademy.com/
49.	Klinghardt Academy - USA	USA	
50.	Nordiska Praktorskolan	Sweden	www.praktor.com
51.	Österreichischen Berufsverband der Kinesiologen	Austria	www.kinesiologie-oebk.at
52.	Praxis Integrative Achberg	Germany	www.integrative.de
53.	Sammenslutningen af Alternative Behandlere	Denmark	www.alternativ-behandling.dk
54.	Schweizerischen Berufsverbandes der Kinesiologinnen und Kinesiologen	Switzerland	www.kinesiologie-ch.ch
55.	Schweizerischer Berufsverband für Kinesiologie	Switzerland	www.iask.ch
56.	Schweizerischer Verband Nicht-Medizinische Kinesiologie	Switzerland	www.svnmk.ch
57.	Svenska Kinesiologiskolan - Swedish School of Manual Kinesiology	Sweden	www.kinesiologi.se
58.	Sveriges Yrkesutbildade Kinesiologer	Sweden	www.kinesiolog.se
59.	The Academy of Systematic Kinesiology	UK	www.kinesiology.co.uk
60.	The Association of Systematic Kinesiology, ASK	UK	www.systematic-kinesiology.co.uk
61.	The British Kinesiology Centre	UK	www.britishkinesiology.co.uk
62.	Topping International Institute Inc	USA	www.wellnesskinesiology.com
63.	Touch For Health Instructors Association - Australia	Australia	www.touch4health.org.au
64.	Touch For Health Kinesiology Association - USA	USA	www.tfhka.org
65.	Vida Kinesiología	Spain	www.vidakine.org/

Discussion

It is conservatively estimated that over 1 million people worldwide were trained in some form of kMMT technique system. However, there are several limitations in this study that may be sources of either overestimation or underestimation in the actual figure. Firstly, there are a number of potential sources of overestimation that must be noted. For example, there are likely redundancies in this calculation, since many kMMT practitioners undertake training in more than one kMMT technique system. Therefore, it is likely that a kMMT trainee has been counted repeatedly. Consequently, this may have inflated the estimation. In addition, it is also likely that not all those trained actually practice or routinely use the kMMT technique system they were trained in, which may also be a source of overestimation of the prevalence of use. Similarly there are a various potential sources of underestimation. For example, if an organisation did not have a presence on the World Wide Web, then it is likely that it was not included in the list (see Appendix Table C.1), and therefore, not contacted. Such would be the case with small or local kMMT educators, not part of a larger organisation. Also not included were organisations that do not use kMMT as part of the formal training, but whose practitioners routinely use kMMT within the technique system in practice. One example of such an organisation is BodyTalk. With over 100,000 people trained in BodyTalk to date, it is a noteworthy omission. However, BodyTalk does not officially teach kMMT, but uses another similar dichotomous test to navigate through a session (John Veltheim, personal communication, 2010). Nevertheless, kMMT is used routinely by BodyTalk practitioners, as can be evidenced by a simple search for “BodyTalk” on the website www.YouTube.com. Another example of this is with Emotional Freedom Technique (EFT), which is practiced widely around the world and is rapidly growing in popularity. Like BodyTalk, EFT purportedly does not teach seminar attendees to use kMMT, but EFT practitioners have been

known to use kMMT in practice with EFT protocols. Therefore, these may be other sources of gross underestimation of the prevalence of use of kMMT.

It might be noted by some critics that there are some technique systems included in the list that some practitioners would argue do not use kMMT. One example would be Applied Kinesiology (AK), which mainly uses MMT in the way Kendall and Kendall describe.[1, 10, 11] However, many AK practitioners use one indicator muscle for therapy localisation, which can be considered a form of kMMT; and therefore, AK and AK practitioners were included in this survey. Likewise, Sacro Occipital Technique (SOT), a commonly-used chiropractic technique[i], is not considered a kMMT-technique per se. Nevertheless, SOT practitioners use the "arm fossa test" and another test called "body language" during assessment of a patient, which can also be considered forms of kMMT.[58, 179, 201] Therefore, SOT and SOT practitioners were also included in this report.

Taking into account the results of this survey and these potential sources of over- and underestimation, the prevalence of use of kMMT can be conservatively inferred to be over 1 million practitioners worldwide.

The implications of these results are significant. The prevalence of use is extensive, and yet kMMT is not accepted as a valid assessment tool and even considered by some to be charlatanism.[21, 87-91, 93-95, 221] This suggests an urgency to undertake rigorous research to explore the true usefulness of kMMT in clinical settings. The first step in this process should be to determine its clinical validity by undertaking diagnostic test accuracy studies.[73] A second step would be to determine its precision (i.e. reproducibility and repeatability);[73] that

[i] SOT has been found to be used by approximately 40% of American chiropractors [Christensen, M. G., Kerkhoff, D., Kollasch, M. W., & L., C. (2000). Job analysis of chiropractic, 2000: A project report, survey analysis and summary of the practice of chiropractic within the United States. Greeley, CO: National Board of Chiropractic Examiners.]

is, whether it can be relied upon in different clinical settings, with the same and different patients, and over various timeframes. Finally, its clinical utility must be assessed, which means answering the question: *Does incorporating kMMT in patient management improve patient outcomes or overall quality of life?*[73] This last step entails assessing the effectiveness of the various technique systems (see Appendix Table C.1) using randomised controlled trials.

The process of validating kMMT is in its early stages. However, the results of this study indicate that the prevalence of use of kMMT is widespread enough to warrant further investigation.

Summary

Through internet searches, personal communication and expert opinion, kMMT has been estimated to be used by over 1 million people worldwide. This estimation might be amplified due to the possibility of redundancies or attrition. Likewise, it might be low due to misclassification or too narrow search methods. Regardless, the widespread use of kMMT merits further consideration, and proper exploration of its usefulness in clinical settings.

APPENDIX D

STARD Checklists

"It is discouraging how many people are shocked by honesty

and how few by deceit."

Noel Coward

APPENDIX D – STARD CHECKLISTS

STARD Checklist – Study 1 – Estimating the Accuracy of kMMT (Chapter 2)

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	47
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	49
METHODS			51
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	52
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	52
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	52
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	51
Test methods	7	The reference standard and its rationale.	57
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	55
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	55
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	52
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	67
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	70
	13	Methods for calculating test reproducibility, if done.	N/A
RESULTS			72
Participants	14	When study was performed, including beginning and end dates of recruitment.	72
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	72

	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	N/A
Test results	17	Time-interval between the index tests and the reference standard, and any treatment administered in between.	75
	18	Distribution of severity of the target condition.	75
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	88
	20	Any adverse events from performing the index tests or the reference standard.	92
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	76
	22	How indeterminate results, missing data and outliers of the index tests were handled.	72
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	83
	24	Estimates of test reproducibility, if done.	N/A
DISCUSSION	25	Discuss the clinical applicability of the study findings.	92,103

STARD Checklist – Study 2 – Replication of Study 1 (Chapter 3)

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	111
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	113
METHODS			115
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	116
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	116
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	116
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	115
Test methods	7	The reference standard and its rationale.	117
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	117
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	117
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	116
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	116
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	119
	13	Methods for calculating test reproducibility, if done.	N/A
RESULTS			120
Participants	14	When study was performed, including beginning and end dates of recruitment.	120
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	120
	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	N/A

Test results	17	Time-interval between the index tests and the reference standard, and any treatment administered in between.	122
	18	Distribution of severity of the target condition.	122
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	131
	20	Any adverse events from performing the index tests or the reference standard.	155
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	155
	22	How indeterminate results, missing data and outliers of the index tests were handled.	154
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	155
	24	Estimates of test reproducibility, if done.	N/A
DISCUSSION	25	Discuss the clinical applicability of the study findings.	161,164

STARD Checklist – Study 3 – Grip Strength Study (Chapter 4)

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	146
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	148
METHODS			149
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	150
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	150
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	150
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	149
Test methods	7	The reference standard and its rationale.	150
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	150
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	151
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	150
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	151
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	153
	13	Methods for calculating test reproducibility, if done.	N/A
RESULTS			154
Participants	14	When study was performed, including beginning and end dates of recruitment.	154
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	154
	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	N/A

Test results	17	Time-interval between the index tests and the reference standard, and any treatment administered in between.	151
	18	Distribution of severity of the target condition.	155
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	155
	20	Any adverse events from performing the index tests or the reference standard.	155
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	155
	22	How indeterminate results, missing data and outliers of the index tests were handled.	154
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	155
	24	Estimates of test reproducibility, if done.	N/A
DISCUSSION	25	Discuss the clinical applicability of the study findings.	161,164

STARD Checklist – Study 4 – Stability Study (Chapter 5)

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	167
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	169
METHODS			170
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	171
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	171
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	171
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	170
Test methods	7	The reference standard and its rationale.	173
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	173
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	173
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	171
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	173
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	176
	13	Methods for calculating test reproducibility, if done.	176
RESULTS			178
Participants	14	When study was performed, including beginning and end dates of recruitment.	178
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	178
	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	N/A

	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	181
	20	Any adverse events from performing the index tests or the reference standard.	181
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	181
	22	How indeterminate results, missing data and outliers of the index tests were handled.	178
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	181
	24	Estimates of test reproducibility, if done.	184
DISCUSSION	25	Discuss the clinical applicability of the study findings.	194,195

STARD Checklist – Study 5 – Emotional Stim Study (Chapter 6)

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	200
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	202
METHODS			203
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	204
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	204
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	204
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	203
Test methods	7	The reference standard and its rationale.	203
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	204
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	206
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	204
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	206
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	207
	13	Methods for calculating test reproducibility, if done.	N/A
RESULTS			208
Participants	14	When study was performed, including beginning and end dates of recruitment.	208
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	208

	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	N/A
Test results	17	Time-interval between the index tests and the reference standard, and any treatment administered in between.	209
	18	Distribution of severity of the target condition.	208
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	220
	20	Any adverse events from performing the index tests or the reference standard.	209
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	209
	22	How indeterminate results, missing data and outliers of the index tests were handled.	208
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	215
	24	Estimates of test reproducibility, if done.	N/A
DISCUSSION	25	Discuss the clinical applicability of the study findings.	222,227

POSTFACE

“Imagination is more important than knowledge.”

Albert Einstein

Final Thoughts

Throughout the implementation and analysis of these studies, I found myself pondering a number of important questions about this research, such as: What is Truth? What is a Lie? Are all lies conscious? Can one lie nonconsciously? Is truth absolute or relative? Universal or personal? Answering these questions is beyond the scope of this dissertation; however, from my experiences over the last few years, I will posit these speculations: Truth is personal. Truth is dynamic and Truth is transient. Truth is conscious ***and*** Truth is nonconscious – and these two truths may differ. True lying, paradoxically, requires intent to deceive. Which may be nonconscious. All told, Truth is complex.

Lastly, before embarking on this DPhil programme, I was warned by a number of colleagues that my "life would never be the same again." Little did I know what exactly this meant. And luckily I did not, because had I known, it is likely I never would have taken that first step. Throughout these 7 years, as I progressed past each mile marker on this journey, things and people and principles and ideas that I held dear began one by one to drop away, until now, at the end, I feel as if I arrive naked, unencumbered, seeing things as they really are.

Getting to this point had its share of difficulties. At various times during this odyssey, I have lost jobs, friends, mentors, and my memory. I have changed continents a half dozen times. I have been heckled, harassed and hated, dismissed, disregarded and disparaged – by those, surprisingly enough, from within my own faction (i.e. alternative medicine) and by those from the "other side" (i.e. conventional medicine). I have been asked to answer to broad, sweeping attacks on the chiropractic profession as a whole – by my colleagues in primary

care[i]. I have also had to answer to blatant assaults on the usefulness of an evidence-based practice approach and scientific methodology in general – by my esteemed colleagues in chiropractic[ii]. The Universe has truly tested my resolve.

On the other hand, I have been truly blessed as well. I have learned how to stand on my own two feet. I learned I have a voice and how and when to use it. I have learned the value of true friendship. I have learned to follow the light, to always follow the lightness. I have loved and laughed more than I thought possible. I have expanded in ways previously inconceived. I have grown up, grown into myself. And for this I am delighted – and infinitely grateful.

Yes, it has been an interesting and evolutionary personal journey: One I would not change for the world.

[i] For examples: “So, tell me, what evidence IS there for chiropractice anyway??” (Name withheld, personal communication, 20 May 2009); And “Chiropractors are as useful as a boar with ...” (Name withheld, personal communication, 2011).

[ii] For example: "I'm not part of the Priestly Class of the Church of EBM. I'm sorry Anne, that ‘House of Cards’ does not apply to chiropractic ... your confidence that RCTs capture MUCH -- if ANY -- of the clinical realities actually faced by real doctors and real patients may be misplaced...or a religious belief – ‘Scientism’ ... Still, AK and MMT groups must play that game to get published in the Holy Roman Apostolic Catholic Church of today's EBM Religion...even though I know its sheerest nonsense." (Name withheld, personal communication, 4 April 2014)

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"Our duty is to believe that for which we have sufficient evidence,

and to suspend our judgment when we have not."

John Lubbock

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