MUSCLE TEST COMPARISONS OF CONGRUENT AND INCONGRUENT SELF-REFERENTIAL STATEMENTS

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Summary. This study investigated differences in values of manual muscle tests after exposure to congruent and incongruent semantic stimuli. Muscle testing with a computerized dynamometer was performed on the deltoid muscle group of 89 healthy college students after repetitions of congruent (true) and incongruent (false) self-referential statements. The order in which statements were repeated was controlled by a counterbalanced design. The combined data showed that approximately 17% more total force over a longer period of time could he endured when subjects repeated semantically congruent statements ($p < .001$). Order effects were not significant. Overall, significant differences were found in muscle test responses between congruent and incongruent semantic stimuli.

Applied kinesiologists have long employed the use of the manual muscle test as an indicator of altered physiological function (Goodheart, 1964; Leisman, Zenhausern, Ferentz, Tefera, & Zemcov, 1995). The premise is that a given muscle will be less able to resist outside force when there is some alteration in nervous system function (Walther, 1988). In such a situation, the muscle "breaks," i.e., can no longer sustain the outside force, sooner than if there is no alteration in nervous system function. We will refer to this reaction as muscle "give-way." When performing manual muscle testing, a particular muscle or muscle group is first isolated, then an external force is applied to take the muscle from an isometric to an eccentric contraction (Lawson & Calderon, 1997). The muscle test is subsequently said to be "weak" or "strong" based upon the muscle's ability to resist an external applied force over time.

Walker (1992) proposed that the muscle test responds to cognitive and emotional stimuli. Although there has been no objective investigation of the muscle test for such stimuli, the concept that motoric function is affected by cognitive and emotional factors has been suggested by others as well. For example, performance in sports activities is known to be influenced by affective and cognitive states such as anxiety and self-doubt (Burton, 1988; Gould, Jackson, & Finch, 1993). Emotional stimulation also can cause specific spinal reflex activation (Bonnet, Bradley, Lang, & Requin, 1995). Recently, De Melo and Laurent (1996) reported that the specific components of movement kinematics (movement amplitude, duration, velocity, and acceleration) are influenced by affective state, remarking that this is an under-investigated topic. It should be noted that cognitions and emotions (affects) are not always well-differentiated in the literature, which may be due to how closely the two are linked.

Walker (1996) has formulated a clinical treatment protocol that involves using a manual muscle test to identify cognitive and emotional information that may negatively affect patients' well-being. This protocol was used by Peterson (1997) with phobic patients, resulting in decreased intensity of phobic symptoms; however, this investigation did not specifically study the muscle test itself.

The purpose of the present study was to examine whether opposing cognitive stimuli modulate the muscle test. Congruent (what is known to be true) and incongruent (what is known to be false) self-referential statements were used. The study design was intended to minimize any possible subject or examiner bias. A computerized dynamometer was used for muscle testing. The hypothesis was that congruent and incongruent statements would yield significantly different values for total force and time required to reach muscle give-way.

METHOD

Subjects

A total of 89 right-handed undergraduate students (61 women and 28 men) participated in this study for course credit in an introductory psychology class. Their ages ranged from 18 to 24 years. Subjects were excluded if they were not American citizens, reported being left-handed, had significant shoulder dysfunction or prior experience with muscle testing.

Apparatus

Muscle testing was performed using a PowerTrack II dynamometer with Tracker software from JTech Medical Industries. The basic technical set-up may be described as follows: (1) The dynamometer's transducer was connected to a NEC/Versa computer. (2) The transducer registered total force (examiner pressure and subject resistance combined) and time to muscle give-way. (3) This information was immediately recorded by the computer software, creating graphs of real-time and force.

Using such an apparatus indirectly controls for examiner bias, especially if the muscle is tested to give-way while the subject is resisting to the best of his ability. For example, if an examiner used less force in a situation when he did not want the subject to demonstrate muscle failure that would otherwise occur, it would be reflected in the dynamometer's reading of total force; total force would be lower. Total force is the combined value of pressure applied by the examiner (examiner force) plus resistance offered by the subject (subject force). So, in this example, even though the muscle does not give way as quickly, there is a lower value for total force because examiner's force is decreased, and, as subject's force cannot exceed the examiner's, the subject's force also is lower. Therefore, there are three ways to demonstrate enhanced muscle resistance in one condition over another: (a) total force is significantly increased with time to muscle give-way being relatively equal, (b) time to muscle give-way is significantly increased with total force being relatively equal, and (c) both variables of total force and time to muscle give-way are significantly increased.

Also, total force rates, i.e., force applied plus force resisted or time to give-way, are calculated from the computer-generated graphs. If the subject is resisting the examiner's force from the beginning of the trial, then the force rate most closely reflects the rate of pressure applied by the examiner. For example, if the examiner applies a large amount of pressure to overcome a muscle quickly to demonstrate less resistance than ordinarily present, it would be reflected by an increased force rate. Therefore, force rates need to be consistent across trials to demonstrate differences in resistance.

A dynamometer is a more practical and relevant apparatus to control examiner's force than using a steady load against the patient's muscle because (a) pressure needs to be applied incrementally, until muscle failure or give-way occurs and (b) it would be difficult to impossible to know what load weight to use in different subjects with varying muscle strength, especially when the presumption is that a different amount of force is required in different test situations within subjects. For example, using too small a weight for a particular subject might result in no muscle give-way, regardless of the test condition. Conversely, using too large a weight for a particular subject's muscle strength could result in overpowering the tested muscle, regardless of the test condition. Moreover, there is demonstrated reliability of muscle strength measurements using hand-held dynamometry (Bohannon, 1997a, 1997b).

Procedure

Ninety-five subjects completed an informed consent form and baseline survey which included questions about medical problems, shoulder dysfunction (the test utilizes the anterior deltoid muscle), and previous experience with muscle testing and nationality. Handedness was measured using a reliable, global question developed by Coren (1993). One of the subjects reported an old injury that was no longer bothering him; he felt comfortable with participating and was permitted to do so. Five potential subjects were excluded because they were left-handed, and another was excluded because she was not an American citizen (see below).

To isolate the deltoid muscle group, subjects raised one arm to a 90° angle, perpendicular to the front of the body, keeping the elbow straight. The transducer, which was held by the tester, was placed and centered (to allow for a consistent vector) just above the subject's wrist. The tester's other hand was placed on the subject's contra-lateral shoulder to stabilize the upper body. Subjects were carefully positioned such that the torso was as straight as possible, shoulders were level, and extended arm was level with shoulders. Subjects' arm position was calibrated between trials by an experienced musculo-skeletal clinician who was blind to statement sequences. This clinician also checked the body position of the person performing the muscle testing, to ensure consistency of force vectors. Muscle testing was performed by a physician who had over six years of kinesiologic muscle testing experience.

Subjects were seated comfortably, and it was explained that pressure would be applied to the extended arm each time a statement was repeated and that they should resist the pressure as much as possible, i.e., prevent the arm from going down. Subjects were assured that there were no "right" or "wrong" responses. A practice trial was performed without a test statement to familiarize subjects with the mechanics of the muscle test. Immediately after subjects repeated out loud one of the self-referential statements, they would be instructed to push up against the examiner to initiate an isometric contraction. The examiner would then incrementally apply pressure, taking the subject to an eccentric contraction until give-way was achieved. The same instructions were read to all subjects, and examiners did not know the total force and time values from the dynamometer until all trials were completed. There is high reliability when the muscle test is performed in this manner (Hsieh & Phillips, 1990).

Four self-referential statements were used in the study, two true and two false:

> My name is......................(Subject's "real" name or preferred nickname).
> My name is......................(If subject was a male "Alice" was used. If female, "Ralph" was used).
> I am an American citizen.
> I am a Russian citizen.

A counterbalanced design was used to control for order effects. We were concerned with order effects for two reasons. (a) It was conceivable that a different effect might occur if subjects were exposed to a true statement, then a false one as compared to a false statement, then a true one. Also, (b) it was conceivable that, if we tested subjects on only one arm, fatigue might influence the data over four trials. To address these issues, subjects were assigned to one of two conditions. (1) Subjects were exposed first to a true statement, then a false statement, another false statement, and lastly another true statement (TFFT) or (2) subjects were exposed first to a false statement, then two true statements, and lastly a false statement (FTTF). Subjects were randomly assigned to each condition in similar proportions (TFFT = 51.1%, FTTF = 48.9%). Male to female subject ratios were also similar in each condition. To minimize fatigue, only two statements were tested on each arm. For consistency, the right arm always was tested for the first two statements, and the left arm always was used for the second two. There was a 1-min. rest between statements. By employing this process, both true and false statements occurred an equal percentage of the time in each of the four test positions. Moreover, the four trials per subject also allowed for counterbalancing within subjects. All subjects were exposed to both a true statement, then a false statement as well as a false statement, then a true statement.

After testing was completed, subjects were debriefed using the following questions: (a) What do you think the purpose of this study was?, (b) What results do you think we expected?, (c) Did you notice a difference in your ability to resist pressure after repeating the different statements? If so, was that surprising to you?

RESULTS

Time and Force by Trials

Table 1 provides descriptive analyses of the trials. Means, standard deviations, and ranges for each trial are indicated. For example, the first row in this table (false-first time) would be interpreted as "On average, subjects displayed muscle tension for 1.09 sec., with a standard deviation of.40 sec., the first time they were exposed to a false statement.

A major concern in this study was order effects, which prompted the counterbalanced order of statements. To determine whether the order of the different statement sequences of both test conditions (TFFT and FTTF) affected time to muscle give-way an analysis of variance was performed. An alpha level of .05 was used to classify all findings as either significant or non-significant. The analysis showed that order (TFFT or FTTF) did not significantly account for the variance in time to muscle give-way ($F_{1,87} = 1.63$, ns), An analysis of variance was also performed to assess the influence of order on total force. As in the first analysis, the results were non-significant ($F_{1,87} = 0.25$, ns). Moreover, force-rates were compared for true and false statements (as measured from start to muscle failure). No significant differences were found between the two conditions ($t_{68}=1.93$, ns). Overall, these findings clearly suggest that the order of the test conditions did not significantly influence the results.

TABLE 1
Measured standard deviations of time (sec) and force (lb) trial (N = 89)

Trial		M	SD	Range
False	Time 1 sec* Time 2	1.09 1.05	0.40 0.44	0.01-2.20 0.40-3.45
True	Time 1 Time 2	1.62 1.78	0.60 0.85	0.40-3.30 0.55-5.60
False	Force 1 lb.†	18.9 19.4	7.3 7.0	0-45 8-42
True	Force 2	22.4 22.7	8.3 7.5	11-52 8-44

*Time = time to muscle give-way. †Force = total force (examiner's force + subject's force).

Self-referential Statements

The primary. question of this investigation was "Does the congruence of verbal statements affect the muscle test?" As seen in Table 2, congruent (true) self-referential statements were associated with significantly higher scores on measures of both time and total force as compared to incongruent (false) statements. Similarly, when data was combined within subjects, there was a 58.9% longer time to muscle give-way with a 17.2% higher total force when responding to true statements ($p < .001$) in either arm. In addition, the effect sizes (r) reported in Table 2 ranged from .57 to .86. This phenomenon is illustrated in Fig. 1.

TABLE 2
Ratios for true versus false statements on time and force variables

Trial	M	t	r
False - Time 1, sec* True - Time 1	1.09 1.62	10.07‡	.57‡
False - Time 2 True - Time 2	1.05 1.78	10.07‡	.60‡
False - Force 1, lb. † True - Force 1	18.9 22.4	7.36‡	.85‡
False - Force 2 True - Force 2	19.4 22.7	6.38‡	.79‡
Overall false Time, sec Overall True Time	1.07 1.70	11.22‡	.61‡
Overall False Force, lb. Overall True Force	19.2 22.5	8.00‡	.86‡

*Time = time to muscle give-way. †Force = total force (examiner force + subject force) ‡ $p<.001$

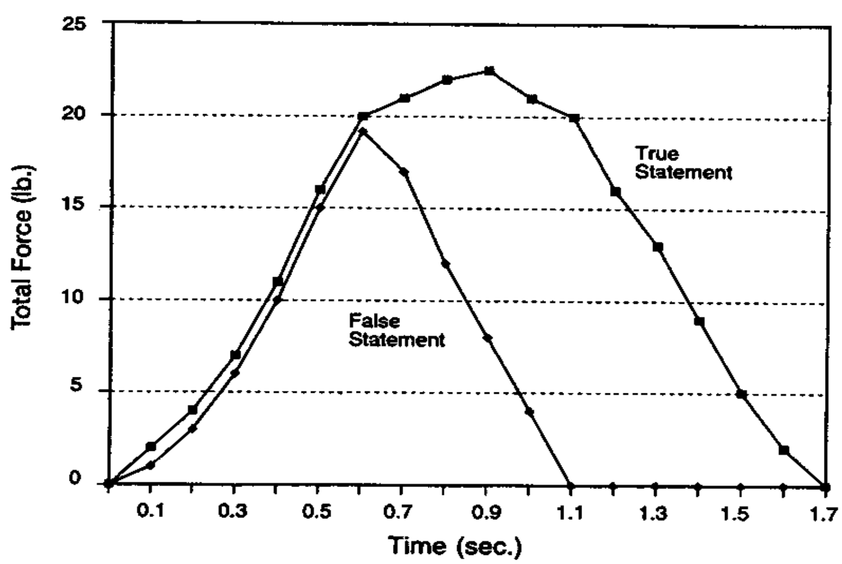

Fig. 1. Typical profile of subject performance during muscle testing for true versus false self-referential statements.

Debriefing Questions

The debriefing questions were analyzed and provided additional information on subjects' expectation bias. Data were missing for three subjects. Of the remaining 86 subjects, 60 (70%) reported that the purpose of the experiment was to study something in muscle or body physiology, which is what subjects were told prior to participation. Twenty-two individuals (26%) stated that they did not know or had no idea, and four thought there was some hidden agenda. When asked what results they thought we were expecting, 44 subjects (51%) responded that they thought we were looking at physiological functions of some sort but stated nothing about differences in muscle strength. Thirty-one (36%) stated that they did not know or had no idea about our expected results. Eleven (13%) stated in some form the hypothesis of our study; nine of those 11 felt they arrived at the hypothesis after noticing the differences in their ability to resist pressure. The last question asked subjects if they noticed any differences in their ability to resist applied pressure with respect to any of the questions. Only 15 subjects (17%) were aware of differences in the muscle test, and all were surprised by this.

Responses of Men and Women

Lastly, sex differences were explored. On average as expected, the men had statistically significantly higher scores than women on both the time and force variables for all trials ($p < .05$).

DISCUSSION

Muscle testing following congruent and incongruent self-referential statements indicated that muscle give-way was associated with a total force peak that was approximately 17%, higher, over a 59% longer period of time following semantically congruent (true) statements (see Fig. 1). The order of statements did not significantly influence responding. The present data suggest that cognitive discrepancies can affect the muscle test.

Examiner bias was controlled by the function of the muscle-testing apparatus. Specifically, if the examiner was biased toward demonstrating a stronger muscle test for a particular type of statement and thereby delivered a lower pressure to increase the time to muscle give-way, the result would be a lower value of total force, which would not support the examiner's bias for a stronger muscle test. Conversely, if the examiner attempted to use a significantly greater pressure to increase the total force value, the time to muscle give-way would likely be significantly decreased, essentially countering the bias. In our group, both total force and time were increased overall with the congruent statements (see Fig. 1). No significant differences were found in comparing the force rates of congruent and incongruent statements.

It is unlikely that subjects' bias significantly affected responding. Only subjects who were naive to muscle testing participated, and they were instructed that there were no "right" or "wrong" responses to the statements. Moreover post test debriefing indicated that very few subjects were aware of what was actually being tested or of what was expected.

It is possible that the results of the muscle testing reflect the subjects' autonomic reactions to making statements that are congruent or incongruent. Autonomic reactivity to such stimuli is extensively documented in the literature on biofeedback (Levenson, Ekman, & Friesen, 1990; Cacioppo, Uchino, Crites, Snydersmith, Smith, Berntsen, & Lang, 1992) and polygraph testing (Pennebaker, Hughes, &

O'Heeron, 1987; Bradley & Cullen, 1993). In recent years, studies using electromyography have indicated changes in electrical activity in muscles when subjects are presented with physiologically arousing emotional stimuli (Bradley, Cuthbert, & Lang, 1996). Also, the presentation of consonant and dissonant stimuli can affect task performance (sometimes referred to as "Stroop" performance), which is associated with measurable autonomic changes (Renaud & Blondin, 1997).

It is possible that the results are related to the changes in brain activity when congruent and incongruent statements are uttered. For example, true and false self-referential statements similar to those used in our study design were evaluated with electroencephalogram (EEG) by Fischler, Achariyapaopan, and Perry (1985) who found a discrete measurable change in the ongoing EEG signal, following the repetition of false statements. This EEG signal change (called an N400) was not present with true statements. It is not known what neural pathways are affected when an N400 occurs. One possibility is that limbic projections to the motor cortex are affected, which is the proposed mechanism for some of the physiological reactions seen in biofeedback (Basmajian, 1989). Clearly, further research is required to elucidate the possible neuro-anatomical and biochemical processes involved in the muscle test responses observed. As mentioned previously, there have been reports of clinical interventions which use the manual muscle test to assess patients' congruency of cognitive and emotional stimuli (Walker, 1996; Peterson, 1997). However, there had been no objective evaluation of the muscle test for that purpose. The results of the present study suggest that the muscle test responds to the congruency of self-referential statements. Potential clinical applications of this observation will require further investigation.

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