# Precise Measures of Source Credibility as a Multidimensional Concept[1]

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October 2, 2017
Revised April 18, 2018

[1] We are grateful to Anthony DiBartolomo, Jingy Zhou, Taylor Manfredi, Phillip Campbell, Connor Marquart, Ian Underwood, Jenna Hornberger, Paul Schmitt, Daniel Hector, MacKenzie Uline, and Ashna Kapoor for help in this research

Almost 24 centuries ago, Aristotle laid down the theoretical structure that has provided the foundation for research on persuasion until today. The effectiveness of a persuasive message, according to Aristotle depends on three factors – ethos, pathos and logos:

> "Of the modes of persuasion furnished by the spoken word there are three kinds. The first kind depends on the personal character of the speaker; the second on putting the audience into a certain frame of mind; the third on the proof, or apparent proof, provided by the words of the speech itself. Persuasion is achieved by the speaker's personal character when the speech is so spoken as to make us think him credible.... his character may almost be called the most effective means of persuasion he possesses" (Aristotle and Roberts ca 350 BCE).

Although seldom made explicit, virtually all modern scientific analysis of source credibility begins with Aristotle's classification, including the pioneering work of Hovland, et. al. (DEMİRDÖĞEN* 2010, Hovland 1951, Hovland 1953, Hovland 1949) and continuing today.

So far, Aristotle's theory has held up well under the scrutiny of modern social science. Perhaps the most robust finding in the persuasion literature is that the effects of persuasive messages delivered by less credible sources (low ethos) are smaller than those of messages delivered by highly credible sources (high ethos). Kaplowitz and Fink consider this "well known":

> What variables determine the value of α, the constant of proportionality? To answer this question we consider what other source, message, and receiver factors are known to affect the persuasiveness of a message.
>
> 1. Because it is well known (see, e.g.,(Aronson 1963); (Hovland 1951), (Jaccard 1981) that a more credible source produces more persuasion, we can conclude that the more credible the source, the greater is α. (Kaplowitz and Fink 1997)

The idea that a less credible source should be less effective at persuasion than a more credible source seems intuitively obvious, perhaps because it's been a foundation of Western cultural beliefs for 24 centuries, and few bother to ask why source credibility should matter at all. The most common reason cited for the reduced effectiveness of messages delivered by low-credibility sources is also implicitly based on Aristotle's theories of the human psyche, the combination of teleology (goal orientation or voluntarism) and the notion of "free will"; since I know that the source is not believable, I freely choose not to be persuaded:

> "…not knowing how to deal with it *they prefer to ignore the message altogether*" (Kağıtçıbaşı 2008) cited in (DEMİRDÖĞEN* 2010) (emphasis supplied).

The Problem

But is it possible to freely choose to ignore incoming information?

While the reduced effect of messages delivered by less reliable sources appears to be a reliable empirical finding supported by considerable research, the idea that people freely choose to disregard such messages remains a speculation unsupported by any empirical evidence. In fact, a solid body of empirical findings in neuroscience[2] and artificial neural networks casts considerable doubt on the possibility that acceptance or rejection of information can be controlled voluntarily.

Perhaps the most fundamental finding of the research on neuroscience and artificial intelligence for understanding the functioning of intelligent systems is Hebb's rule: neurons that fire together wire together (Hebb 1949, Lee H 2014). In organic systems, neurons firing in proximity generate chemical reactions that facilitate communication among neurons in the short term and growth of structural connections among them in the long term. In artificial neural networks, simultaneous firing of artificial neurons results in increasing the coefficients representing the connections among the artificial neurons.

In practice, this means that when a source S sends a message M to a receiver R, neural connections between S and M, S and R and M and R will all be strengthened. There is no scientific research whatsoever that indicates this process might be subject to voluntary control. A person can no more "choose" not to link the neurons implicated in the message than he or she could choose not to make use of calories already ingested. There is nothing in the literature of neuroscience or artificial intelligence to indicate that neuroplasticity is in any way affected by an individual's perception of the source of the stimulus as favorable, unfavorable, trustworthy, untrustworthy, credible or not, or any other characteristic whatever.

So, if unpleasant or unwanted information cannot be voluntarily disregarded, how can we explain the solid empirical result that less credible sources appear to have less effect on attitudes than more credible sources?

Theory

Any network, including any neural network, organic or artificial, can be modeled as a matrix where the nodes represent neurons and the cells represent the degree of connection between the nodes intersecting at that cell. The eigenvectors of this matrix represent a coordinate system in which the nodes (neurons) are represented as position vectors, or, if we consider only

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[2] That Aristotle's theory could withstand a century of social science inquiry only to fall prey to neuroscience seems entirely appropriate, since his concept of the brain's function was entirely wrong: "And of course, the brain is not responsible for any of the sensations at all. The correct view is that the seat and source of sensation is the region of the heart."

the ends of the vectors, as points. Since there are likely in excess of 80 billion neurons in a single human brain, such a matrix would be quite unwieldy (and probably quite sparse).

Without loss of generality, we can model tightly interconnected nodes or neurons as individual clusters representing perceptual objects. These also can be represented as a matrix in which the nodes represent clusters of interconnected neurons or 'concepts", and the cells represent the degree of connection among the clusters. Similarly, the eigenvectors of this matrix constitute a coordinate system in which the concepts are located as points, with highly interconnected concepts close to each other, and less tightly interconnected or negatively interconnected clusters far apart.

Within this model, the source, receiver and message content can all be represented as points (or vectors) in the space. Similarly, a message can be modeled as a statement simultaneously activating the nodes representing the source, the receiver and the concepts in the message. According to Hebb's rule, this results in an increase in the connections among these objects, and these increases will be expressed as motions in the vector space as the "distances" among the concepts are reduced[3]. In general, the "meaning" of any message can thus be expressed as the weighted vector average of all the concepts implicated in the message, or

$$\mathbf{M} = \sum \alpha_i \mathbf{m}_i / N,\ i=1,N$$

Where $\mathbf{M}$ = the resultant vector
$\alpha_i$ = a weighting factor for the ith message component[4]
$\mathbf{m_i}$ = the ith message component vector
N = the number of message components in the message.

This resultant vector **M** would be the position vector of the location toward which the component vectors would converge. This vector could take on any orientation whatever in the multidimensional space, and needs to be determined empirically.

From the outset, persuasion research has generally limited itself to the use of one-dimensional scales, such as the number of paratroopers in a photograph (Fisher and Lubin 1958), number of hours of sleep (Bochner and Insko 1966), and the like as dependent variables. It is clearly possible, and no doubt very likely[5], that the motion in the vector space spanned by the

[3] The magnitude of the increase in connection strength and the corresponding reductions in distance depend on factors is outside the scope of this paper, but see Barnett (Barnett, G. A. 1988. "Frequency of Occurrence as an Estimate of Inertial Mass: Pigs in Space." Pp. 243-64 in *Readings in the Galileo System: Theory, Methods, and Application* edited by G. A. Barnett and J. Woelfel. Dubuque, IA: Kendall/Hunt. MacIntosh; Kaplowitz, S. and Edward L. Fink. 1997. "Message Discrepancy and Persuasion." in *Progress in Communication Science Xiii*, edited by G. A. Barnett and F. T. Boster. Norwood, NJ: Ablex.

[4] In this research, we will set all alphas to 1. See note 3 above.

[5] In fact, the likelihood that the motion generated by the message would lie completely in the direction of the dependent variable would be vanishingly small.

concepts will not be wholly projected on the one-dimensional vector along which the dependent variable is measured. In other words, the message might well be expected to cause motions at non-zero angles from the dependent variable. These motions could not be detected by the dependent variable, no matter how precisely measured. This could easily make the message appear to be less effective, no matter the true magnitude of the motion generated by the message.

The purpose of the present research is to measure the total change (motion) produced by a message delivered by credible and less credible sources.

## Methods

Since the motions predicted by the current theory might occur at any orientation in a multidimensional space, a multidimensional measuring tool is required. Moreover, since we are attempting to estimate magnitudes of change, a scale capable of measuring magnitudes consistently across experimental conditions is required. Both of these requirements are satisfied by the Galileo measurement system (Woelfel and Fink 1980).

The Galileo model selects a set of concepts that define a neighborhood or domain, and selects an arbitrary pair of concepts (often but not always taken from the neighborhood being measured) and sets the perceived difference or distance between this "criterion pair" as a standard against which the distances among all other pairs of concepts in the neighborhood are judged as ratios to the standard distance (Thurstone 1927, Woelfel and Fink 1980).

## Experimental Design

In a national Gallup survey of 805 adults in the US conducted in December 2014, nurses were ranked the most ethical and honest profession, while members of congress were rated the least ethical and honest. In a random assignment to condition post-test only design, NNN undergraduate students at a large Northeastern public university were assigned to one of three experimental conditions: a control condition, in which students received a questionnaire which stated "This questionnaire will ask your opinions about the Health Care Reform Act (HCRA)"; a high-credibility condition, which stated "This questionnaire will ask your opinions about the Health Care Reform Act, which a committee of nurses said was beneficial and attractive."; and a low-credibility condition which stated "This questionnaire will ask you about the Health Care Reform Act, which a committee of members of congress said was beneficial and attractive."

All students received identical Galileo type questionnaires requiring respondents to estimate the (12X11)/2=66 differences or distances among 12 concepts: beneficial, attractive, trustworthy, credible, nurses, members of congress, good, HCRA, unreliable, untrustworthy, health and yourself. To serve as a reference, they were told that reliable and unreliable were 100 units apart.

**Please estimate how different or "far apart" each of the following words or phrases is from each of the others. The more different,**

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or further apart they seem to be, the larger the number you should
write. To help you know what size number to write, remember
   RELIABLE AND UNRELIABLE ARE 100 UNITS APART
 If two words or phrases are not different at all, please write
 zero (0).  If you have no idea, just leave the space blank.

     Thank you very much for your help.

            ------------------------------------------------------
             RELIABLE AND UNRELIABLE ARE 100 UNITS APART
       COL.  ------------------------------------------------------
0102    9-17  BENEFICIAL              and  ATTRACTIVE              _____
0103   18-26  BENEFICIAL              and  TRUSTWORTHY             _____
0104   27-35  BENEFICIAL              and  CREDIBLE                _____
0105   36-44  BENEFICIAL              and  NURSES                  _____
0106   45-53  BENEFICIAL              and  MEMBERS OF CONGRESS     _____
0107   54-62  BENEFICIAL              and  GOOD                    _____
0108   63-71  BENEFICIAL              and  HCRA                    _____
0109   72-80  BENEFICIAL              and  UNRELIABLE              _____
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Figure 1: Instructions and first eight of 66 paired comparisons of Galileo questionnaire

**Results**

One hundred fifty useable questionnaires resulted. Since the criterion pair (reliable and unreliable are 100 units apart) was considered an extreme distance, the maximum value filter was set at 101. This resulted in the elimination of 32 values from the control group, 34 values from the *nurses* condition and 35 values from the *congress* condition. Altogether, 101 values were eliminated, which was 1.0% of the 9,900 total values in the sample. Final sample sizes ranged from 36-43 in the control group, 40-56 in the nurses condition and 35-51 in the congress condition. Average sample sizes for the three conditions were 40.8, 48.8 and 48.5 respectively for an overall average sample size of 138.1.

Galileo measurement precision at these sample sizes is good, with percent relative errors in the control group (the smallest sample) ranging from a low of 5.0% to a high of 20.3%. The smallest distance in the control group was 17.0 (*trustworthy* and *credible*), the largest was 76.6 (*unreliable* and *beneficial*). The average distance was 49.8.

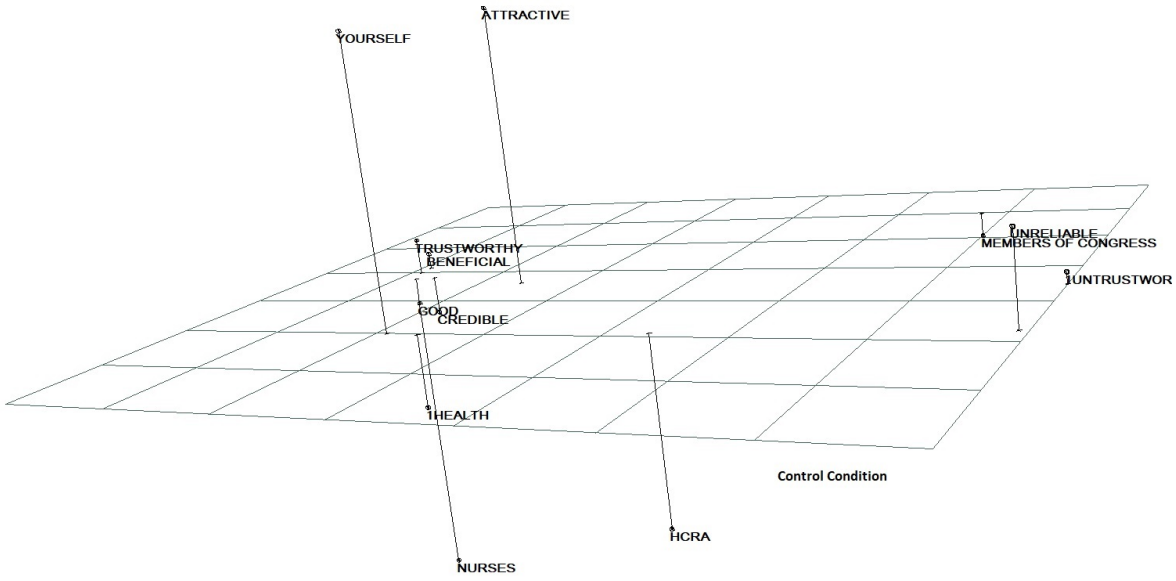
The resulting space was multidimensional, with eight real (1-8) and 3 imaginary dimensions (10-12) in the control condition (dimension 9 represents rounding error). The largest real dimension was 89.8 units long, while the smallest was 14.9 units. The largest imaginary dimension was 40.6i, while the shortest was 9.7i.

| Table 1: Correlation Between Dimensions Treatment and Control | | | | |
|---|---|---|---|---|
| | Nurses | | Congress | |
| Dimension | correlation | angle | correlation | angle |
| 1 | .97 | 12.6 | .99 | 6.6 |
| 2 | .98 | 9.3 | .86 | 0.3 |
| 3 | .87 | 29.0 | .87 | 29.0 |

| | | | | |
|---|---|---|---|---|
| 4 | .92 | 21.7 | .88 | 28.1 |
| 5 | .74 | 42.2 | .83 | 32.9 |
| 6 | .17 | 99.8 | .19 | 78.7 |
| 7 | .23 | 76.4 | .71 | 49.7 |
| 8 | .32 | 71.1 | .45 | 62.7 |
| 9 | .08 | 94.6 | -.04 | 92.5 |
| 10 | .01 | 89.4 | .36 | 68.4 |
| 11 | .87 | 28.9 | .84 | 3.4 |
| 12 | .96 | 14.3 | .97 | 12.2 |

Treatment groups were rotated to least squares best fit on the control group leaving the treated concepts (beneficial, attractive, HCRA and nurses in the *nurses* condition, and beneficial, attractive, HCRA and members of congress in the *congress* condition) out of the minimization calculation using Galileo version 5.7 software. Table 1 shows that the first five real dimensions (1-5) and the last two (largest) imaginary dimensions (11-12) are quite stable across control/treatment for both treatment conditions showing that the space is reliably multidimensional and non-Euclidean.

Figure 1 shows a graphic plot of the first three dimensions of the control condition.




Even though Figure 1 does not represent all the variance in the multidimensional space, it's clear from the first three dimensions that members of congress (located to the right of the picture) are viewed as untrustworthy and unreliable. Nurses, on the other hand, are located toward the left bottom (directions in the space are arbitrary) near *Health* and much closer to *trustworthy* and *reliable* than members of congress. Nurses are also closer to *Yourself*, which

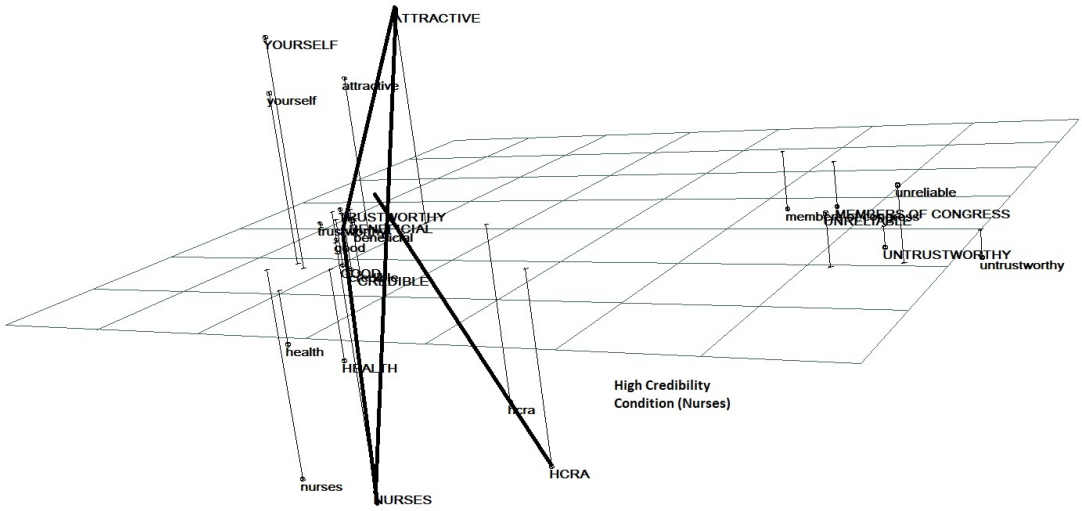
represents the average self-point of the respondents, while members of congress are quite distant. Table 2 gives the exact distances.

| Table 2: Distances from Nurses, Members of Congress | | | | |
|---|---|---|---|---|
| Concept | Nurses | | Members of Congress | |
| | Distance | Standard error | Distance | Standard error |
| Trustworthy | 24.0 | ± 4.1 | 59.0 | ± 5.3 |
| Credible | 27.1 | ± 4.5 | 55.0 | ± 5.4 |
| Good | 27.5 | ± 4.9 | 56.7 | ± 9.0 |
| Unreliable | 68.6 | ± 5.1 | 41.9 | ± 5.0 |
| Untrustworthy | 64.6 | ± 5.4 | 37.5 | ± 5.0 |
| Health | 22.3 | ± 4.4 | 61.8 | ± 4.3 |
| Yourself | 65.3 | ± 4.7 | ± 73.4 | ± 4.8 |

Table 2 shows clearly that Nurses are believed to be more trustworthy, credible and good, less unreliable and untrustworthy, closer to health and the self, while members of congress are less trustworthy, less credible, less good, more unreliable, more untrustworthy, further from health and the self.

**High Credibility Condition**

In the high credibility condition, respondents read the following message: "This questionnaire will ask your opinions about the Health Care Reform Act (HCRA), which a committee of nurses said was beneficial and attractive." From the point of view of the HCRA, the message contains three components: *beneficial, attractive* and *nurses*. These three components form a triangle in the space, and the (unweighted) average of these vectors points toward the center of that triangle. Figure 2 shows both the control group (all caps) and the *nurses* condition (lower case) plotted on joint coordinates.

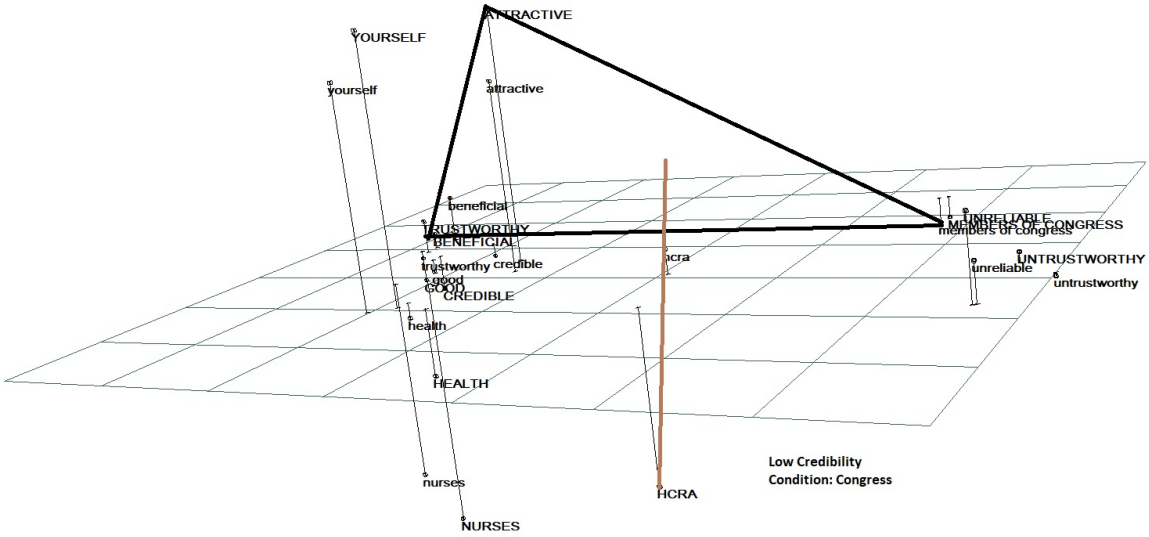



The apparent trajectory of the HCRA (from the HCRA in caps in the control condition to HCRA in lower case in the high credibility condition) lies on a line that appears to pass very near to the center of the triangle. The actual angle between the unweighted predicted trajectory and the observed trajectory is 45 degrees, corresponding to a correlation coefficient[6] of .703 (sig. <.05).

**Low Credibility Condition**

In the low credibility condition, respondents read the following message: "This questionnaire will ask your opinions about the Health Care Reform Act (HCRA), which a committee of members of congress said was beneficial and attractive." From the point of view of the HCRA, the message contains three components *beneficial, attractive* and *members of congress.* These three components form a triangle in the space, and the (unweighted) average of these vectors points toward the center of that triangle. Figure 3 shows both the control group (all caps) and the *congress* condition plotted on joint coordinates.

[6] The correlation between vectors in a Riemannian space is not identical to correlation in a flat Euclidean space, since some of the coordinates are imaginary, and their squares are negative.




Again, the apparent trajectory of the HCRA (from the HCRA in caps in the control condition to HCRA in lower case in the low credibility condition) lies on a line that appears to pass very near the center of this very different triangle. The actual angle between the unweighted predicted trajectory and the observed trajectory is 51 degrees, corresponding to a correlation coefficient of .648 (sig. <.05).

Analysis

The test concept, HCRA, moves in both the high credibility and the low credibility condition, albeit in different directions. In fact, the actual amount of movement in both conditions is nearly identical: 41.28 units ± 11.9 in the high credibility (nurses) condition and 36.37 units ± 13.0 in the low credibility (congress) condition[7]. The angle between the motion vectors of HCRA in both conditions is 82.4 degrees, corresponding to a correlation of -.157, which is not significant.

The Hebbian theory does not predict that all the motion will occur in the focal concept (HCRA), but rather that all the concepts in the message will approach each other as their synaptic connections strengthen. Table 2 shows how much each of the message concepts moves in the two conditions:

Distances Moved

[7] The amount of change advocated by both conditions is nearly the same (169.8 units in the *nurses* condition and 179.2 units in the *congress* condition) because the distance from the HCR to *beneficial* and *attractive* is constant in both conditions (58.4 and 67.4), and HCRA is nearly equidistance between *nurses* (44.02) and *congress* (53.3).

| | Nurses | Congress |
|---|---|---|
| HCRA | 41.28 | 36.37 |
| Beneficial | 22.93 | 20.03 |
| Attractive | 37.84 | 44.02 |
| Nurses | 17.69 | 7.4 |
| Congress | 10.14 | 2.67 |
| Total | 102.05 | 100.42 |

Here, too, the total amount of motion in the high credibility condition and the low credibility condition are nearly identical. What is different, however, is the direction of the motion. Notice in all three figures above that the self-concept lies to the left of the space. When the HCRA moves toward the Nurses/Attractive/Beneficial triangle in Figure 2, it moves closer to the self-point. On the contrary, when it moves closer to the Congress/Attractive/Beneficial triangle, it moves roughly parallel to the self-point. Table 3 shows the actual distances:

| | Distance HCRA-Self | |
|---|---|---|
| | Mean | SD |
| Control | 52.667 | ± 5.1 |
| Nurses | 43.279 | ± 5.6 |
| Congress | 48.649 | ± 5.5 |

Clearly, while the less credible source (congress) produces the same amount of attitude change, it produces it in a different direction, and hence appears to be less effective.

## Discussion

When the social disciplines attempted in the early 20$^{th}$ century to emulate their more successful colleagues in the physical sciences, among the characteristics of science they most noticed were the functional relationships among variables in famous theories, such as F=ma and E=MC$^2$. Early quantitative research methods textbooks often began with the notion of variables and constants, which they represented by lines and line segments. Concepts of space were virtually absent from early methodological texts. Quantitative methods concentrated on establishing (essentially linear) relationships among variables. Early emphasis on statistical techniques such as significance levels created a focus not so much on how variables were related but rather on the statistical odds that they were related at all. In a sense, social scientists were unable to read between the lines.

**References**


Aristotle and Trans by W. Rhys Roberts. ca 350 BCE. *Rhetoric*.

Aronson, E., Turner, J. A., & Carlsmith, 1. M. . 1963. " Communicator Credibility and Communication Discrepancy as Determinants of Opinion Change.". *Journal of Abnormal and Social Psychology* 67:6.

Barnett, G. A. 1988. "Frequency of Occurrence as an Estimate of Inertial Mass: Pigs in Space." Pp. 243-64 in *Readings in the Galileo System: Theory, Methods, and Application* edited by G. A. Barnett and J. Woelfel. Dubuque, IA: Kendall/Hunt.

Bochner, S. and C. A. Insko. 1966. " Communicator Discrepancy, Source Credibility, and Opinion Change." *Journal of Personality and Social Psychology* 4:7.

DEMİRDÖĞEN*, Ülkü D. 2010. "The Roots of Research in (Political) Persuasion:
Ethos, Pathos, Logos and the Yale Studies of
Persuasive Communications." *International Journal of Social Inquiry* 3:12.

Fisher, Seymour and Ardie Lubin. 1958. "Distance as a Determinant of Influence in a Two-Person Serial Interaction Situation." *Journal of Abnormal and Social Psychology*:8.

Hebb, D. 1949. *The Organization of Behavior. A Neuropsychological Theory*. New York: Wiley.

Hovland, C.I., & Weiss, W. . 1951. "The Inflouence of Source Credibility on Communicaion Effectiveness." *Public Opinion Quarterly* 15:17.

Hovland, C.I., Janis I.L., & Kelley H.H. 1953. *Communication and Persuasion*. New Haen: Yale University Press.

Hovland, C.I., Lumsdaine. A.A., & Sheffield, E.D. 1949. *Experiments on Mass Communication*. Princeton: Princeton University Press.

Jaccard, J. 1981. "Towards Theories Ofpersuasion and Belief Change." *Journal of Personality and Social Psychology* 40:9.

Kağıtçıbaşı, Ç. 2008. *Günümüzde İnsa Ve İnsanla*. Istanbul: Evrim.

Kaplowitz, S. and Edward L. Fink. 1997. "Message Discrepancy and Persuasion." in *Progress in Communication Science Xiii*, edited by G. A. Barnett and F. T. Boster. Norwood, NJ: Ablex.

Lee H, Brott BK, Kirkby LA, Adelson JD, Cheng S, Feller MB, Datwani A, Shatz CJ. 2014. "Synapse Elimination and Learning Rules Coregulated by Mhc Class I H2-Db." *Nature* 509(509(7499)):6.

MacIntosh, R and J. Woelfel. 2017. "Inertia in Cognitive Process: Pigs in Space Redux." *Communication and Science Journal*.

Thurstone, L. L. 1927. "Alaw of Comarative Judgment." *Psychoogical Review* 34:13.

Woelfel, J. and E.L. Fink. 1980. *The Measurement of Communication Processes: Galileo Theory and Method*. New York: Academic Press.

(MacIntosh and Woelfel 2017)