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RESEARCH ARTICLE

Perspectives on the Role of Triangulation in Medicine and Health Care

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We consider the use of triangulation— the idea that we should examine a given phenomenon from a number of angles to get a "rounded appreciation" for the phenomenon in question— in health care. *Viewing triangulation itself from a number of perspectives (e.g., related approaches, philosophical underpinnings, examples of applications), we argue that some form of triangulation will often prove useful to the researcher and clinician, though the approach has limitations and which form, if any, should be used in a given situation depends on context.*

Keywords: *Eclecticism, perspectivism, dialectics, scientism, EBM*

I. TRIANGULATION – THE BASIC IDEA.

"[A] complete elucidation of one and the same object may require diverse points of view which defy a unique description."
Niels Bohr's *Complementary Principle*

The basic idea behind triangulation is to view some (complex) phenomenon from a number of angles to get a "rounded appreciation" for, or a more complete picture of, the phenomenon in question. We believe that Mary Midgley's [1] "one aquarium, many windows" metaphor is instructive in this context. Consider a large aquarium with a number of windows allowing simultaneous viewing of parts of that aquarium by multiple viewers. The view from any one window does not allow complete understanding of the contents of the whole aquarium:

> "We *cannot have a single comprehensive view of the whole aquarium—a single all-purpose, philosophic Theory of Everything … The world is simply too rich for such reductive straight-jacketing*" (p. 19).

But this does not say that we are unable to improve upon our restricted view—all we need do is recognize our limitations and admit the possibility that others may be able to help us learn. Midgley continues,

> "*This does not mean no understanding is possible. We can relate these various aspects rationally because they all occur within the framework of our lives. We can walk around and look at the other windows and can discuss them with each other. But we cannot eliminate any of them. We have to combine a number of different ways of thinking—the view through several windows, historical, biological, mathematical, everyday and the rest – and somehow to fit them together*".

The windows into a 'medical aquarium' will include biological, chemical, historical, psychological, political, and evolutionary portholes, all of which may play a role in medical decision making; and the observation that we "can discuss them with each other" finds a familiar analog every time we discuss a case with a colleague, order additional tests, decide to consult an expert, or the patient asks for a second opinion.
Figure 1 captures the basic idea:

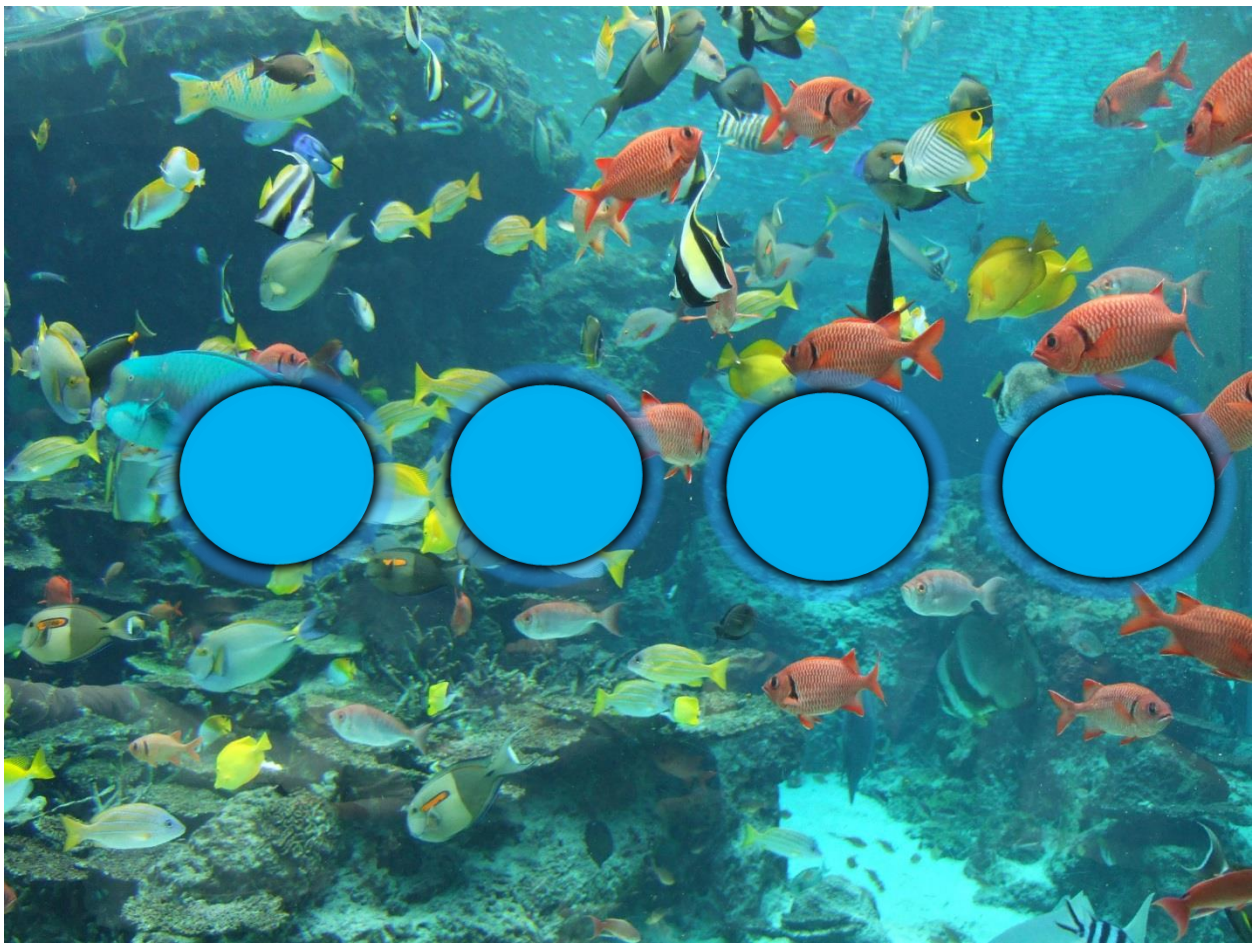

Figure 1. The World as an Aquarium. Four possible viewing windows are shown

Windows (not shown) at the sides and on the opposite side will afford different views of the (same) aquarium. Adopting a single ideology, be it scientism or religion, would restrict our view of the aquarium to just one window. If we can just *not do this*, if we can allow that more windows are desirable and, even, necessary, we might be able to facilitate a dialogue between the parties. A panacea? No, but we submit it as useful first step in assembling the tools most useful in understanding the workings of the world.

The above metaphor involves several different observers of the phenomenon in question. We do not, however, exclude the case of a single observer who utilizes varying views in order to best appreciate the situation. A simple everyday example of this can be seen on the putting green at any professional golf tournament. There it is commonplace for a given golfer, faced with a putt whose roll is apt to be influenced by changes in topography on the way to the hole, to look at the terrain leading up to the hole from a number of different angles. This does not make for compelling TV, but it does make clear the importance of taking all available information into account. This sort of scenario is depicted in Figure 2.

Figure 2. The importance of judging the roll from a number of different angles

Another one of Midgley's metaphors, that of "many maps of the same territory," is useful in covering the case of a single observer. Midgley [2] employs the "many maps" metaphor, which was discussed in detail in *Science and Poetry* to make the point that we need *scientific pluralism*—the idea that there are many independent forms and sources of knowledge; rather than *reductivism* – the conviction that one fundamental form underlies them all and settles everything. She considers the many maps of the world that are found in the first pages of atlases and notes that we do not make the mistake of thinking that these maps conflict. We know that the political world is not a different world than the climatological one, that it is the same world seen from a different angle. Different questions are asked, so naturally there are different answers.

These metaphors are useful to Midgley since she takes a holistic, one-world's approach to looking at things: There is but one world; what we have are

many ways of looking at that world. Each of these ways may be useful for answering a specific sort of question. No way is "the correct way". And, while she recognizes but one world, she emphasizes that it is a big one [3], and that its complexity requires that we take in the information about it that are provided by alternative views and integrate their contributions into a unified whole.[a] We take it that the fact that the world is complex needs no documentation.

II. TRIANGULATION – A DIALECTIC

Having collected the views of the phenomenon in question from a number of angles, we need to have a way to reconcile these alternative viewpoints. If, e.g., different people are looking through the different windows at an aquarium we will have to have them talk to one another so as to reach this "rounded appreciation." We suggest that reconciliation will be best achieved by a way that views the alternative viewpoints as complementary, not competing. This reflects our choice of epigraph for this paper: Niels Bohr's *complementary* principle. In our development, we stress "generous thinking" as defined and developed by Fitzpatrick [4]:

> *"Generous thinking, a mode of engagement that emphasizes listening over speaking, community over individualism, collaboration over competition, and lingering with the ideas that are in front of us rather than continually pressing forward to where we want to go"* (p. 4).

She details how generous thinking can be used to regain public trust in our universities, but also indicates other potential avenues for application and connections to what may seem at first glance to be quite divergent areas of interest, most notably a close correspondence with improvisational comedy (IMPROV)'s "rule of agreement", which is based on four core principles:

- "Yes, and …"
- Full presence
- Deep listening
- Have each other's back

Briefly, "Yes, and..." refers to a focus on agreement, accepting what you agree with and adding to it. This stands in opposition to "No, but…" Full presence refers to a focus on the ideas in front of us and not on pressing on to individual, predetermined endpoints. The aim is to gain a consensus, not determine the winner of a debate. Deep listening involves not only listening to *what* others think; but also *why* they think that way. Finally, remember that this is not a competition, rather equal partners in a search for the truth (or a laugh, depending on context).

Adhering to these principles does not guarantee that no disagreement will occur. Often, apparent disagreement will result from mutual misunderstanding when not all parties are "speaking the same language." There is a need to develop a common language. This won't necessarily eliminate all disagreement, but it may help to get us past those of little consequence.

Fitzpatrick's generous thinking and the core principles of IMPROV bear a close resemblance to two other developments that have taken place in still other seemingly disparate contexts. These are mentioned briefly below, mainly to emphasize the pervasiveness of triangulation even within our own development – different people, at different times and places, addressing different problems, all converging on a single set of desiderata that we now recognize as having widespread application. When all roads lead to Rome, Rome must have something going for it. In the present context, the various modes of discourse considered all point to treating the diverse viewpoints as complementary, not competing, and to treating participants in the discourse as partners, not competitors, in their common quest to arrive at the truth.

The first is partnership theory which is developed in terms of so-called Partnership and Domination models. These were conceived and developed by Riane Eisler [5,6,7,8] as a new social paradigm that transcends conventional social categories such as religious vs. secular, right vs. left, capitalist vs. socialist, and East vs. West. As outlined by them:

A *domination system* is a system of top-down rankings ultimately backed up by fear or force, e.g., man over man, man over woman, race over race, religion over religion, and man over nature. It has four core elements:

- Top-down control in families, economies and states, all institutions in-between
- Rigid male dominance along with the devaluation by both men and women of anything considered "feminine"
- The acceptance, even idealization, of abuse and violence as a means of imposing one's will on another
- The idea that dominating or being dominated is inevitable and desirable.

Examples: Nazi Germany, Stalin's Soviet Union, Fundamentalist Iran, the Taliban.

A *partnership system*, on the other hand, has a more democratic and egalitarian structure. It is based on the belief that equal partnership and mutual

respect are normal and desirable. It consists of four core elements:

- A more egalitarian and democratic structure in the family, economy, and state
- Equal partnership between men and women
- Low level of abuse and violence (since they are not needed to maintain rigid rankings of domination)
- The belief that relations of partnership and mutual respect are normal and desirable.

No relationship is purely domination or partnership. Rather, there is a partnership/domination continuum, no matter whether the relationship is between husband and wife, parents and children, or the state and its citizens. It's always a matter of degree.

This allows us to escape the trappings of dichotomization [9]. We no longer have to deal with binary comparisons, no more male vs. female, religious vs. secular, right vs. left, capitalist vs. socialist, and East vs. West. Rather, we recognize a partnership/domination continuum and the fact that the mix in any particular situation depends on context.

Our final example is that of ingressive vs congressive thinking, a contrast that was developed as part of what is called category theory, a mathematical theory designed to replace the theory of sets in foundational mathematics. Whereas set theory depends on the notion of set *membership* (a given element is either in or out), category theory focuses on the *relationship*(s) between elements. We do not attempt to describe the mathematical details here; rather we adopt the approach taken by Cheng [10] who used the theory to escape the traditional male/female dichotomy and allow a more nuanced analysis of the concept of gender. Cheng contrasts ingressive and congressive thinking as follows:

>Ingressive: focusing on oneself over society and community. More competitive and adversarial than collaborative.

>Congressive: focusing on society and community over self. More collaborative and cooperative than competitive.

This, as was the case in partnership/domination, is not a clean dichotomy; not a one-dimensional "either or." Nobody is 100% ingressive or congressive in thought all of the time. Rather, it will be a mix of the two and the proportions will depend on context. Thus, we depart from dichotomous, "either/or" thinking and go to a more "both/and" stance.

The above considerations speak to the importance of "multiple windows." Surely, when one considers many medical decision-making questions, the idea of including the perspective from the viewpoint of improvisational comedy does not immediately come to the fore. Yet, the idea of having "equal partners in search of the truth" has parallels in the doctor/patient relationship where the common goal should be finding the best course of prevention/treatment for the patient given current circumstances. Clinicians may rankle at having their pronouncements questioned and many patients will recoil from having any say whatsoever in what is seen as strictly a scientific question, but while the science *is* necessary and important, it is generally not sufficient, and will profit from the view afforded by, e.g., the 'patient preference' window[11]. The partnership model fits the doctor/patient relationship much better than the domination model. The same is true in more general triangulation scenarios: Participants need to be partners and dialog between the participants viewed as complementary, as all are vested in learning the truth and not in winning a debate.

III. TRIANGULATION PHILOSOPHICAL UNDERPINNINGS

Triangulation has an obvious connection to the philosophical schools of thought called eclecticism and perspectivism. Eclecticism is a conceptual approach that does not invariably use a single model, the same set of assumptions, or one-and-the-same paradigm in every situation, a grand overarching Theory of Everything. Rather, it exhibits flexibility, drawing upon multiple models, sets of assumptions, theories, styles, or ideas to gain complementary insights into a subject, or applies different theories in particular cases. An example of this last point is not hard to find: Most psychologists accept certain aspects of behaviorism, but do not attempt to use the theory to explain *all* aspects of human behavior. More generally, practicing psychologists will use whatever approaches and techniques deemed appropriate for their client. They take multiple perspectives into consideration while identifying, explaining and changing the behavior of their client.

Perspectivism echoes much the same sentiments, but focuses on multiple observers, each straining to paint an objective picture of a given phenomenon. It rejects objective metaphysics, holding instead that no evaluation of objectivity can transcend cultural influences or subjective evaluations.

The two schools of thought, while similar in many ways, have diverged in practice, eclecticism seen as mainly supportive of triangulation, perspecticism largely negative in that, as developed by Nietzche and others, it has led to the postmodern view that *no* real knowledge is available to human aspirants. The crown prince of this postmodern perspective is Nietzsche who offered the movement's mantra: *There are no facts, only interpretations*. No truths, only opinions. Thus, any attempt to discern facts from observation is flawed by the "fact" that different people can inspect the same item and offer widely disparate descriptions. Nietzsche also advanced the idea that individuals were condemned to see the world from a partial and distorted perspective, one defined by their interests and values.

Our view is that Nietzsche got one part of this correctly but went too far in his conclusion. This view is fully in accord with the intermediate view offered by *transcendental perspectivism*. Transcendental perspectivism challenges Nietzsche's claim that there are no absolute truths while fully accepting his observation that all truth can only be known in the context of one's own perception.

To see the force of the importance of individual perceptions on interpretations consider the following examples of differing perspectives on the same thing. This small sampling of representative examples use common everyday language and are based on well-known proverbs:

- The early bird gets the worm VS Haste makes waste.
- Birds of a feather flock together VS Opposites attract
- Look before you leap VS He who hesitates is lost.
- Nothing ventured, nothing gained VS Better safe than sorry.
- The only thing constant is change VS The more things change, the more they stay the same.
- Two heads are better than one VS Too many cooks spoil the broth

We consider this last set of dueling proverbs in more detail. "Two heads are better than one," is a saying whose apparent staying power speaks to its veracity. Many will agree with it – "Sure," being a not uncommon response. However, there will be some who will counter with "Too many cooks spoil the broth," and this has some well-deserved traction as well, but one need not feel obliged to pick one over the other – to choose one and only one as a guiding principle in every situation. The lesson to be learned is that both have merit *under certain circumstances*. The choice between them will depend on the circumstances. On context. There will be situations in which two heads are indeed better and in such instances two (or more) heads should be employed (investigator triangulation). In other situations, it may be that best to invest available resources into strengthening the one-dimensional look. Hofstadter and Sander [12] point out the fact that proverbs are experience-based (as opposed to logically derived) will *mean* that different people take different perspectives in a given situation, and thus may invoke differing, even contradictory proverbs to represent their view. They then provide their own list of pairs of mutually contradictory proverbs to prove their point.

Another set of examples demonstrating the pervasiveness and power of perspective in what it is possible to learn through observation is provided by the Escher's graphic artwork [13]. Escher was a Dutch graphic artist distinguished by his interests in the nature of space, the unusual, perspective, and multiple points of view. The mathematical basis of some of his work was discussed by Doris Schattschneider [13] who pointed out that relativity states that what an observer sees is influenced by context and vantage point, using Escher's lithograph *High and Low*, in which the same structure is seen as a floor (by an observer looking down) and as a ceiling (by an observer looking up). The scene also illustrates how pasting local views together to form a global whole can lead to contradictions. Hofstadter [14] pointed out that each local region of Escher's Ascending *and Descending* is quite legitimate – what you see is what you get – but when they are globally put together, they create an impossibility.[b] These examples relate to the fallacy of eclecticism – the belief that many partial views add up to a complete picture of the phenomenon studied – which we consider later.

Escher's artwork provides many examples of the point we wish to make, namely that perspective needs to be taken into account if we are to somehow reconcile differing viewpoints on the same phenomenon. But one need not resort to Escher's level of complexity and nuance for this purpose. Figure 3 drives this point home without requiring any study.

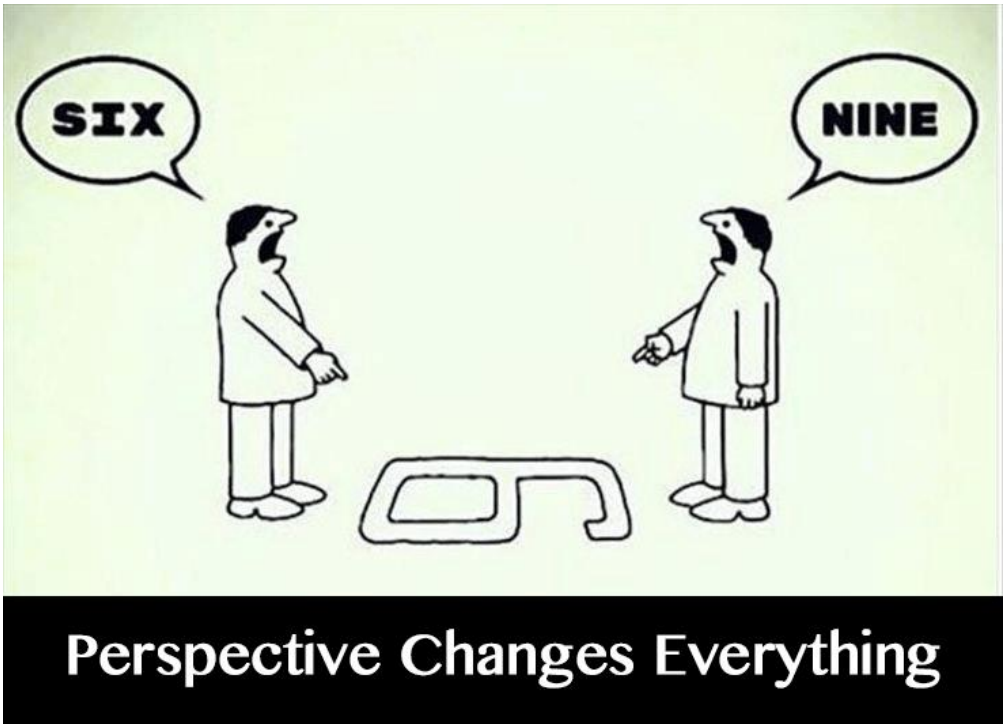

Figure 3. The importance of perspective.

We do concede the point that perspective changes everything; that different viewpoints may lead to different conclusions about a given phenomenon. But one need not conclude from this that we are doomed to cynicism; that no *real* knowledge can ever be achieved. We adopt *transcendental perspectivism* [c] which challenges Nietzsche's claim that there are no absolute truths while fully accepting his observation that all truth can only be known in the context of one's own perception (epistemology is different than ontology).

There is no reason to assume that we are forever trapped in a single perspective or that different perspectives cannot be ranked according to accuracy [15]. And if we can move from one perspective to another, what is to prevent us from conjoining our partial views into a reasonably objective picture of the world? [16]

We might even go so far as to envision a revised form of "objectivity" as an integration of individual viewpoints that represent, for example, a particular idea in apparently contradictory ways but upon closer inspection would reveal a difference of contextuality and permit the development of a rule by which such an idea can be validated. "Truth" is thus created by integrating different vantage points together.

Of course, this "closer inspection" would have to be a joint venture between *serious* inquirers into the truth of the matter, and not undertaken in a debate format designed to produce a "winner" and "loser".[d] Fitzpatrick's [4] "generous thinking" would be required, as would Piaget's "mature intelligence" (Recall Jean Piaget's famous definition of *mature intelligence* as the ability to coordinate between multiple perspectives (or possible perspectives)). Congressive thinking rather than ingressive. The Partnership model rather than domination.

IV. TRIANGULATION – SOME PRECURSORS

In this section, we consider two methodologies that have been developed to deal with data that has been gathered from differing perspectives. The first is multitrait-multimethod matrices (MTMMMs). While the attendant literature seldom mentions "triangulation," it seems to be a good, concrete, simple example of the soul of the technique. In addition, the technique is often used in situations in which the *intent* is a mixture of *confirmation* and *completeness*, which as will be seen later, are two of the most important uses to which triangulation has been put. In particular, in the MTMMM context, it is often of interest to show that the results of different methods converge, while the traits are viewed as distinguishable aspects of a "composite trait" which is the object of the study.

A multitrait-multimethod matrix is a correlation matrix obtained when each of a number of traits is measured by each of a number of methods. A

matrix of this type was first suggested by Campbell and Fiske [17] for investigating the validity of tests as measures of psychological constructs. The intent was to assess convergent and discriminant validity. C*onvergent validity* is the extent to which a test correlates with different measures of the same construct. *Discriminant validity* is the extent to which the test does not correlate with measures of different constructs. The basic idea is that measures of the same trait should correlate higher with each other than they do with measures of different traits involving separate methods. In addition, these validity values should also be higher than the correlations among different traits measured by the same method. Consider, for example, three traits, each assessed by three methods. The structure of the MTMMM is illustrated in Table 1. Here, the sub-matrices with 1s in the diagonal are the (symmetric) *heterotrait-monomethod* blocks, while the sub-matrices with Hs in the diagonal are the (non-symmetric) *heterotrait-heteromethod* blocks. The Hs are referred to as the *validity diagonals*.

	T1M1	T2M1	T3M1		T1M2	T2M2	T3M2		T1M3	T2M3	T3M3
T1M1	1										
T2M1		1									
T3M1			1								
T1M2	H				1						
T2M2		H				1					
T3M2			H				1				
T1M3	H				H				1		
T2M3		H				H				1	
T3M3			H				H				1

Table 1: The structure of an MTMMM

Campbell and Fiske [17] suggested that the elements of the validity diagonal should be substantial, and that any element of the validity diagonal should be larger than all other elements in the corresponding row and column of its heterotrait-heteromethod block.

This is a bit different than most triangulation setups, illustrating the fact that triangulation can take a variety of forms, depending on our objectives (horses for courses). Here we're not necessarily looking for everything to converge to a unified whole; discriminant validity refers to the ability to distinguish between differing traits. They consider an example in which the three traits are attitude to supervisors, attitude to co-workers, and attitude to work, each measured by three methods, Taylor's projective technique, a Likert rating scale, and an Osgood rating scale. Inspection of the resulting MTMMM supported agreement between the methods, but it was also suggested that the three traits were distinguishable.

This example gives rise to a number of others more closely linked to medical applications, for instance questions surrounding quality of life (QoL). There are a number of traits associated with QoL: Depression, anxiety, activities of daily living, to name just a few. And, a number of methods have been advanced to measure these traits and overall QoL, a global assessment of the contributions of each component [18, 19]. Different choices oi traits and methods will lead to a different MTMMM and address a different QoL issue.

The MTMMM set-up is limited to traits and methods, but the same logic can be extended to treatments, settings, populations, and many other aspects of the research enterprise. Any such extension will be an instance of triangulation.

As an example going beyond the MTMMM boundary, consider another technique, perhaps even more well-known to medical researchers, that reflects the spirit of triangulation, is meta-analysis. Like the MTMMM approach, it is not often mentioned in the triangulation literature, but it personifies the "multiple perspective" way of looking at things. It also has been – and continues to be – the focus of both much praise and biting criticism. Meta-analysis can be described as the examination of data from a number of independent studies of the same subject, in order to determine overall trends; an important component of meta-analysis is the investigation of the consistency of treatment effects across studies often with the view of combining results to obtain "a more accurate picture."

We will consider meta-analysis further in the context of clinical research later. We note here only that for every paper extolling its benefits, there is a contrary view focusing on limitations [20, 21, 22].

V. TRIANGULATING TRIANGULATION

Think about what happens if we take the phenomenon to be studied as triangulation itself. Triangulation of triangulation might then involve, e.g., the use of multiple perspectives and/or investigators to study triangulation.

A cursory review of the literature reveals the bipolar view of it taken by those discussing it – either it is the best thing since sliced bread, or just another example of wrong-headed thinking directed at getting something from nothing. We give a brief sampling of both the positive and negative opinions to indicate the flavor of these viewpoints.

Those who look favorably…

Webb et al. [23]:

> As long as a research strategy is based on a single measurement class, some flanks will be exposed … If no single measurement class is perfect, neither is any scientifically useless … for the most fertile search for validity comes from a combined series of different measures, each with its idiosyncratic weaknesses, each pointed to a single hypothesis. When a hypothesis can survive the confrontation of a series of complementary methods of testing, it attains a degree of validity unattainable by one tested within the more restricted framework of a single method …" (p. 173-4).

Denzin [24]:

> "Unfortunately no single method ever adequately solves the problem of rival causal factors … no single method will ever permit an investigator to develop causal propositions free of rival interpretations… because each method reveals different aspects of empirical reality, multiple methods of observations must be employed … This is termed triangulation and I now offer as a final methodological rule the principle that multiple methods *must* be used in *every* investigation …" [our italics] (p. 26-7).

The very words chosen to describe the triangulation process often paint that process in a favorable light. As noted by Sandelowski [25]:

> "Words such as mixing, blending, merging, complementing, and integrating, are commonly used in discussions of triangulation to imply the combination of at least two entities within the same sphere and across different spheres" (p. 571).

Those who look more skeptically ….

Sandelowski [25] also recognized Escher's connection to triangulation. She thought that while triangulation may take on many forms, there is generally only one of two aims of the exercise: confirmation and/or completeness. To aim at *confirmation* is hope that all of the measures/methods involved will point to the same "reality," in particular, this assumes that one such state of the world exists. Blaikie [26] identifies this attitude with the positivist and realist ontologies. On the other hand, aiming for *completeness* allows for multiple realities, resisting reduction to one (interpretivism entails an ontology in which reality is not some 'thing' that may be interpreted in different ways; it *is* those interpretations). Blaikie [26] concludes that the use of triangulation in research can be misleading insofar as it ignores the ontological and epistemological issues that the use of multiple methods can entail.

Fuller [27] warned against the indiscriminate use of triangulation, which he cites as an example of the so-called *fallacy of eclecticism*, the belief that many partial methods add up to a complete picture of the phenomenon studied (p. 42). He thought,

> "Eclecticism consists of selecting the good parts from a set of ideas and discarding the bad parts. But this process implies that you already know how to do the selecting, and have a standard of judgment to use for evaluating the ideas. If you in fact do, then there is no problem and eclecticism is a valid intellectual process. But if you approach a set of ideas in a state of ignorance then you are not intellectually equipped to pick and choose from among them. You could not know whether what you accepted is true or false." (p. 42).

Fuller also gave an example that illustrated how, even if triangulation was justified in some context, care to follow established rules of inference were still required.[e]

Herein lies the danger of eclecticism if you are going to pick and choose you must already have enough knowledge to do the selecting. This will not be a problem in situations where the many maps metaphor applies – all we need to do is pick the appropriate map, i.e., the map best suited to answer the question posed.

In any event, the sampling of bipolar opinions shown above seems to open the door to a "horses for courses" approach, i.e., the idea that the kind of triangulation, if any, to be employed in a given situation depends on context. In particular, the form of the question we expect to answer will largely determine the tool to be used: The issue determines its own epistemology.

VI. TRIANGULATION IN RESEARCH

"Triangulation has come to mean virtually any more-than-one instance of one or more elements of the research process within a study" [25] (p. 571). Thus, triangulation can be seen as the use of multiple theoretical perspectives/procedures/methods, sources of data, investigators or theories to collect and interpret data about a phenomenon. Typically, triangulation is referred to as mixed methods research to convey an intentional combining of both quantitative and qualitative methods and data in the same study. It provides both deductive and inductive examinations of a research question and uses multiple type of data, both numeric and narrative, to address that question. The mixed method approach integrates quantitative and qualitative data in the same study and results in a synergistic use of data [28]. Mixed methods research originated in the social and behavioral sciences and has more recently been adopted by the health and medical sciences in fields such as medicine, nursing, social work, pharmacy, and mental health [29]. Mixed methods research generally is conducted by an interdisciplinary team because of the different perspectives and skills required in quantitative and qualitative methods and designs.

Creswell and Plano [30] outline four types of research situations that benefit in particular from the use of mixed methods. First is when concepts are new and not well understood and a qualitative exploration provides important insights before quantitative methods can be used. This design is described as exploratory sequential. The second situation is where findings generated with one approach can be better understood with a second source of data. The third is when neither a quantitative or qualitative approach alone is adequate to understand the concept of interest. The last situation is when quantitative results are difficult to interpret and qualitative data gathered in parallel can provide insights. This design is described as explanatory sequential.

Wisdom and Creswell [29] describe their mixed methods research which examines the effectiveness of a patient-centered medical home model designed to provide a primary care approach that aims to improve quality, decrease cost, and improve patient and provider experiences. Shorten and Smith [31] provide examples in nursing framed within 4 different mixed method research designs. Doorenbos [32] describes several mixed methods studies addressing chronic pain management among American Indians using quantitative data from the tribal clinic and interview data from patients on their experiences, perceptions, and decision making regarding pain. Pluye and Hong [33] conducted an examination of citations in Medline to identify mixed methods studies and reported 114 mixed methods studies in the public health literature. Tariq and Woodman [34] examined the role of general practitioners in the UK in their response to potential child abuse situations using quantitative data from the primary care data base in the UK and qualitative data from interviews with the general practitioners, nurses, and families.

Denzin [24] identifies several types of triangulation that are useful in Sociological research. These are summarized and discussed by Kimchi et al [35] in the order shown below. We add examples where triangulation might be useful in medical research.

1. Theory. Involves using more than one theoretical scheme in the interpretation of a phenomenon

This stands in contrast to *scientific monism*, the idea that there is one and only one theory sufficient for understanding all of life's mysteries, a grand, all-encompassing "Theory of Everything." This more expansive approach is known as *scientific pluralism* [36]. For a medical example, consider supplementing a strictly scientistic (proximal: *What?* And *How?*) explanation of a disease process with an evolutionary-medicine (ultimate: *Why?*) interpretation [37]. It is important to note here that we use the word *supplement*, not *supplant*, to describe the use to which the additional information will be put. We discuss this example further below

2. Data. Involves collecting data using different sampling strategies, e.g., collecting data

(a) at different times,
(b) in different contexts,
(c) from different people

Looking at the same people at different times constitutes classical longitudinal, repeated measure designs, staples in medical research toolkits. Different contexts/people might entail comparing the same people treated differently, or comparing different people treated similarly. Taking all three of these together might result in a classical multi-site clinical trial design.

3 Methods. (aka methodological pluralism) Involves using more than one method to gather data.
(a) within-methods (e.g., using both open and closed questions in the same questionnaire)
(b) between-methods (e.g., use of focus groups and structured interviews). Often, this involves the use of both qualitative and quantitative data to describe a phenomenon.

When both qualitative and quantitative data are gathered to investigate a phenomenon, we refer to multimethods (or mixed methods) research. This involves the integration of quantitative and qualitative approaches in the research process and can entail either concurrent or sequential use of these two classes of methods to follow a line of inquiry. The expectation is that combining methods utilizes their complementary strengths and helps to overcome their discrete weaknesses. Integrating mixed methods allow researchers to follow emerging questions, rather than limiting their research to questions that are amenable to one particular method. Multimethod research brings together numbers and narratives, description, hypothesis testing, hypothesis generation, and understanding of meaning and context to provide fuller insight into and greater applicability of the results [38].

4. Investigator. Involves multiple researchers in an investigation.

One look at the list of authors of an article in a medical journal will suffice to establish the ubiquity of this practice.

5. Analysis. Involves subjecting the same data set to different data-analytic schemes. Thus, e.g., a given data set may be analyzed by a series of univariate tests or a single multivariate procedure. Another example would be to use Bayesian inference instead of the classical, frequentist approach.

This is not done often in the medical literature where authors are generally expected to choose a single "best" mode of analysis. That this is a choice of some consequence has a long history in related fields, however [39].

6. Multiple. Involves combining several of the different types mentioned above.

It should be clear that many of the classical clinical research designs [40] can be recognized as one or another or a combination of the kinds of triangulation listed above; and that this recognition can contribute to obtaining more complete solutions to some of our most vexing clinical problems. The first example cited above, theory triangulation, is a good illustration. Supplementing modern medical science with insights from evolutionary medicine has immediate application to an important clinical problem, namely, that of the growing microbial resistance to antimicrobial medications.

The WHO has recognized that antimicrobial resistance is one of the top 10 global public health threats facing humanity and the core premise of research into antibiotic resistance is that it is an evolutionary problem. This means that a great deal of the research into a pressing public health problem will have to reach beyond strictly proximate explanations to incorporate evolutionary insights to arrive at more complete and satisfactory solutions to this complex set pf problems. It is to be stressed that proximate and evolutionary explanations are not alternatives – both are needed to understand the evolving phenomenon of antimicrobial resistance. That evolutionary medicine is not an alternative – but a complement – to modern medical science is made clear in the Preface to Nesse and Williams [37]:

> "*We are urging not an alternative to modern medical practice, but rather an additional perspective from a well-established body of scientific knowledge that had been largely neglected by the medical profession.*"

We do not consider all the combinations of the above kinds of triangulation; rather, we present the list to illustrate that triangulation comes in many flavors. In the following two sections we consider applications in clinical psychology and then a particular combination that has been often employed in medical research – the meta-analysis of clinical research studies. Here, and in the final section, we develop the point that triangulation can be useful in clinical research, and the particular form adopted, if any, depends on context.

VII. APLICATONS IN CLINICAL PSYCHOLOGY

In this section we review some of the ways that triangulation has been used in psychotherapy. In the first,

Banks et al. [41] utilized a triangulation approach to examine evidence of questionable research and reporting practices (QRPs) in the social sciences. Such practices (e.g., selectively presenting hypotheses; "cherry picking" results; adding or removing data and control variables to yield statistical significance) can occur with or without intent, but the consequence is the same: information

is generated and presented with bias toward assertion, which can hinder the development of theory, delay the implementation of evidence-based practice, and, ultimately, compromise the perception and relevance of scientific research.

By conducting a systematic review that encompassed multiple reference points and drew upon numerous settings, samples, and study designs (i.e., observations, sensitivity analyses, and surveys), Banks et al. were able to identify instances where QRPs (1) seemed not to be a problem ("the good"), (2) occurred, but were not overly problematic ("the bad"), or (3) posed a serious threat to the viability of a given study and the inferences made ("the ugly"). The majority (91%) of studies showed evidence of QRPs; however, the extent to which QRPs were problematic varied by type of practice and the frequency with which it was employed.

Hence, the triangulation approach was holistic; it allowed Banks et al. to consider whether concerns are warranted in the context of several different kinds of QRPs; it also contributed to greater confidence in the findings, and a number of recommendations for academic training and publication practices.

Frost and Bowen [42] describe newer ways of gathering evidence for the development of evaluation, intervention, and treatment strategies in clinical psychology. They draw on the "*triangle* of communication", which essentially triangulates the relationship among thoughts, feelings and behavior (i.e., it demonstrates how each influences the other and suggests the need to consider all three aspects when developing assessment and intervention strategies). An equal focus on the contributions of cognitive, emotional, and behavioral data yields thick descriptions of individuals' experience and serves to highlight important clinical issues.

This paper also considers traditional understandings of triangulation as only showing *convergence* in research outcomes. It highlights the potential for gaining insight by drawing on multiple methods and/or data sources, even if those are *divergent or contradictory*. Thus, qualification and contradiction of findings can both be investigated in the pursuit of a holistic perspective on clinical issues.

Frost and Shaw [43] discuss ways in which mixed and multimethod approaches to research (e.g., increased use of qualitative methods alongside quantitative strategies to triangulate data and strengthen conjunct numerical and textual analyses) have gained prominence in clinical psychology. Such approaches encourage questioning and deconstruction of concepts like "outcome" and "change" when considering the function of psychotherapy. Further, mixed and multimethod approaches support methodological pluralism and enable a fuller understanding of patients' needs and experiences by applying different core ontological assumptions to the investigation.

Moran-Ellis et al [44] consider the interchangeable use of terms such as "mixing", "combining", and "integrating", and how these can create epistemological confusion when it comes to triangulation. At the same time, combining the epistemological claims (terms) of differing paradigms allows multidimensional understandings of the phenomena under study "reflections of … different aspects" (p. 49).

Reif et al [45] examined data on substance user treatment services collected via multiple methods and respondents in the nationally representative Alcohol and Drug Services Study. Data were collected from facility director reports, treatment record abstracts, and client interviews. Although any of these sources alone might be adequate, additional information was gleaned by involving multiple sources.

When multiple methods of data collection are available, one particular method is often thought to yield the most accurate and reliable information (i.e., it is considered the "gold standard"). Example from medicine: Laboratory test results are thought to be more valid, reliable, and objective than patient self-report or notes made in the medical record. However, lab tests can be nonspecific or erroneous at times, and the results may depend largely on the individual patient. Further, the absence of a lab test does not necessarily mean a symptom or diagnosis does not exist; it is possible that the symptom was merely not reported or that the diagnosis was simply not noted in the medical record.

It is also true—as we saw with the study of substance user treatment services—that an investigation might involve data from multiple sources where no single source qualifies as gold standard. In that event, researchers cannot rely on the gold standard to check the validity of other

data. However, they can use multiple sources to their advantage by considering the level of agreement among common data obtained by different methods. High concordance provides reassurance of the data source and gives credibility to the findings.

In the context of evidence-based practice and using the example of self-harm, Warner and Spandler [46] identify problems with current approaches to research in clinical psychology (e.g., an overreliance on outcomes that prioritize behavioral measures and an undue focus on treatment techniques). They suggest (a) that traditional behavioral approaches to research can be enriched by qualitative cognitive and emotionally based data, and (b) studies require flexible methods informed by key practice-based principles instead of techniques. Such strategies yield meaningful and context-specific findings that are relevant for clinicians and service users.

"Drawing on pluralistic data sources and methods enhances the interpretations and allows for a more holistic, principle-based development of 'compassionate strategies of support and care' … this information can be triangulated to provide a comprehensive, robust and meaningful picture of the particular service or intervention under scrutiny. Such triangulation requires critical evaluation in order to highlight areas of potential conflict, imbalance, or gaps in service" (p. 24).

VIII, TRIANGULATION IN CLINICAL RESAEARCH – THE EXAMPLE OF META-ANALYSIS

In the context of clinical research, meta-analysis can be defined as quantitative, formal, epidemiological study design used to systematically assess previous research studies to derive conclusions about that body of research. Outcomes from a meta-analysis may include a more precise estimate of the effect of treatment or risk factor for disease, or other outcomes, than any individual study contributing to the pooled analysis. The examination of variability or heterogeneity in study results is also a critical outcome. The benefits of meta-analysis include a consolidated and quantitative review of a large, and often complex, sometimes apparently conflicting, body of literature. The specification of the outcome and hypotheses that are tested is critical to the conduct of meta-analyses, as is a sensitive literature search.

The results of a meta-analyses have taken on an almost mystical "importance," having been elevated to the apex of the pyramid depicting the hierarchy of evidence available from various types of study designs. This is shown in Figure 4, a typical web-available depiction, where meta-analysis is a kind of systematic review.

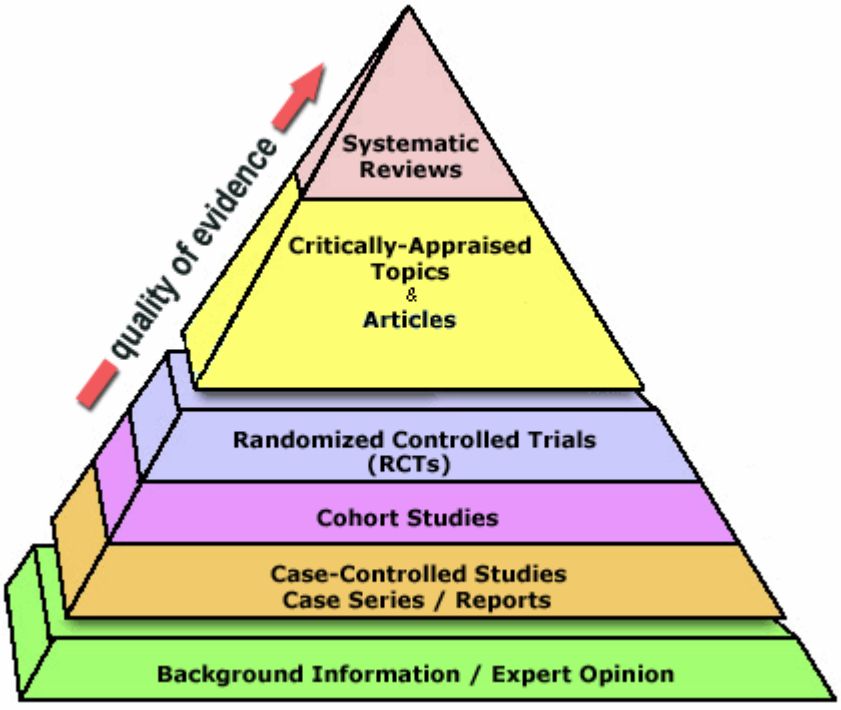

Figure 4. A hierarchy of study types.

A meta-analysis is a special kind of triangulation wherein a single focal point/question has been subjected to a number of different, independent assessments. This may entail a number of different sites, investigators, time frames, patient populations, etc., but the object is to combine these different perspectives to obtain a composite view that is more accurate/trustworthy than any of its components considered in isolation. And, despite the exalted position accorded meta-analysis by proponents of evidence-based-medicine (EBM), others have had serious reservations about these efforts. Indeed, two distinct sides have emerged, one insisting that EBM is both necessary and sufficient for sound clinical decision making, the other, while not dismissing the importance of evidence thinks that it is far from sufficient. Much of the resulting shouting match is, at base, caused by the idea that the RCT is the *only* real, objective form of evidence that *should* be used in clinical decision making. Many EBMers defend this thesis, but others insist that other forms of evidence are often useful and sometimes required to come to a sound conclusion. For example, Upshur et al [47] distinguish between four types of evidence used in health care:

- Qualitative-personal,
- Qualitative-general,
- Quantitative-general, and
- Quantitative-personal

The RCT yields Quantitative-general evidence (numerical outcomes from groups of individuals) and using only this evidence amounts to ignoring the other sources. This would mean *not* using things like patient characteristics, societal attitudes (e.g., towards vaccination), and quality-of –life concerns. In the context of clinical decision making, this clearly has little face validity.

McHugh and Walker [48] discussed the epistemic shortcomings of basing clinical decisions solely on RCT-derived knowledge (which they called "scientism"), and the link between McHugh and Walker's *knowledge* and Upshur et al's *evidence* was provided by Kowalski et al [49] who also gave additional examples of the ways in which scientism could be hazardous to your health.

IX. CLOSING PERSPECTIVES

That triangulation can be applied and is potentially useful in many biomedical research contexts follows directly from the observation that "Triangulation has come to mean virtually any more-than-one instance of one or more elements of the research process within a study" [25] (p. 571). Once one moves beyond the most narrowly focused, tightly controlled explanatory designs [50], it becomes difficult to even imagine a study that *doesn't* qualify.

Triangulation in clinical practice is also easy to demonstrate. Consider the Qualitative-personal to the Quantitative–general dimension of evidence and the following typical clinical scenario in which we traverse this dimension in three distinct steps. The first step comes from the patient who presents a set of symptoms, a clinical history with unique qualities and risk factors, and a socio-economic context. This can be viewed as a first-person account. The second comes from the clinician who assesses clinical signs, develops a clinical profile, and works through a differential diagnosis This would be a second-person account, a mixed qualitative/quantitative-personal assessment. The third comes from unnamed persons who develop guidelines, thresholds for disease diagnosis, standards, normal ranges, and recommended treatment based on best evidence available. This is the third-person account. All three of these steps are required for understanding the extent of the problem presented and the development of a plan for next steps.

This is an example of deliberate multiplication of perspectives to obtain a "fuller picture" of the problem. Anytime a patient requests a second opinion, or a clinician reaches out to consult an expert, or to order additional tests be performed, we see triangulation in action.

Still, one should not assume that just because triangulation has been used somewhere in a clinical decision-making process this assures a definitive answer. Whether triangulation will be useful in a given scenario depends on the situation. Meta-analysis will be of limited value if the aim is to select a course of treatment for this one, individual patient presenting a particular problem; but may be useful to summarize and combine the results of RCTs *if the sole aim of the exercise is to do so*. It needs to be recognized that meta-analysis of RCTs will often yield information limited to efficacy and this will fall short of what we really want to know in many situations. For example, knowing only that a vaccine is effective against COVID-19 will not tell us how many will be willing to get it [51]. This in no way denigrates the importance of knowing how effective the vaccine is (what we can see through the basic biological sciences and biostatistical windows). This information is vital, absolutely necessary, but it is not *sufficient* to answer *all* questions of clinical import.

NOTES

a. Both the many maps and windows metaphors were shown to be important in the study of the relationship between religion and science [52]. The relationship between R&S is complex given that it depends both on time and place and on the interaction between these two factors.

b. An interesting more general setting in which to view Escher's perspectivism (the idea that it is easy to paste together two or more perfectly reasonable ways of depiction and arrive at an unreasonable global depiction) was developed by Douglas Hofstadter, who pointed to some correspondences between the work of Escher, Gödel and Bach. Hofstadter [14] introduced the notion of the "strange loop" to unravel the mystery of how it is that animate beings can come out of inanimate matter – the mystery of "being" or "consciousness." The "strange loop" phenomenon occurs whenever moving upwards (or downwards) through the levels of some hierarchical system, we unexpectedly find ourselves right back where we started.

Notice that a loop represent an endless (infinite) process in a finite way. This "conflict" between the finite and infinite is a recurrent theme in much of Escher's (and Bach's) work.

Gödel enters the picture via the *Epimenides paradox* (or *liar paradox*): *All Cretans are liars*, a stronger version of which is: *This statement is false*. This paradox is a one-step strange loop (like Escher's *Print Gallery*). The proof of Gödel's theorem hinges upon writing a self-referential mathematical statement, in the same way as the Epimenides paradox is a self-referential statement of language.

A related strange loop with several steps (reminiscent of Escher's *Drawing Hands*) is

The following sentence is false.

The preceding sentence is true.

Either sentence taken alone is at least potentially useful. It is only the way that they are "put together" (point at each other) that creates an impossibility. This may be related to Escher's *Ascending and Descending* in which each local region is quite legitimate; it is only when they are globally put together that creates an impossibility.

c. We do not consider transcendental perspectivism in any detail in this paper. For out purposes, it is simply a way to transcend the differing perspectives sure to exist between ourselves and another person (the *other*) when considering a given phenomenon. It focuses on the development of a true partnership between one's self and the *other*, based on compassion for the *other*, by eschewing domination, looking to cooperation and connectedness rather than competition and survival of the fittest. Much of the theory is based on Riane Eisler's work on partnership and some of the practical facets of the philosophy were outlined by Krieglstein [53, 54].

d. There are plenty of examples where "triangulation" has as its target not *truth* but some other, not necessarily bad, outcome. A fairly well-known example is from the political arena where what is desired is compromise (and not necessarily what is best for the governed). In what has become known as "Clintonian triangulation," the aim was to re-elect then President Clinton by setting a platform that not only contained the best ideas of each of the parties, but transcended them to produce a new vision for where the country should go. In so doing, Bill Clinton abandoned some of the usual tenants of the Democratic Party and took a more favorable view of balanced budgets and deregulation, going so far as to declare "the era of big government is over." We are not of the opinion that compromise is never called for, but insist that *intent matters*. To pretend to embrace doctrines *for the sole purpose of re-election* is not the same as looking for what is best for the country. There is a time for compromise as there is a time for sticking with one's principles; and this needs to be decided one case at a time, on a case-by-case basis.

Another example is from psychology, where triangulation is a manipulation tactic where one person will not communicate directly with another person, using instead a third person to relay communication to the second, thus forming a triangle. It also refers to a form of splitting in which one person manipulates a relationship between two parties by controlling communication between them.

e. Fuller [27] also discusses an oft-cited example of triangulation in the sociological literature, James Coleman's The Adolescent Society, which identified a high school subculture in the United States, more oriented toward athletics and extracurriculars than toward academics. Data were collected from students, parents, and school personnel including questionnaire, interview and school record data. The problem was that almost all the findings concerning students were obtained from questionnaires, while most of the findings about the adults were from interviews.

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