Confronting Inductive Inference (at last): Concepts from Aeronautical Engineering Can Lead to Advances in Social Psychology

Introductory note

Kenneth Hammond never stopped having ideas and never stopped working. At the time of his death in 2015, aged 98, he was working on a paper with his assistant Zoë Lang. That paper was presented by her and discussed at the 2017 Brunswik Society meeting in Vancouver. The paper was a draft and has never been published. Although incomplete, the paper is included here as a reminder of Hammond's life-long effort to encourage social psychologists to confront the problem of making valid inferences from their experiments, a problem that continues to plague the discipline.

In the paper, Hammond and Lang describe how the "Reynolds Number" has helped aeronautical engineers deal with their problem of generalizing from models in wind tunnels to actual aircraft. They suggest that a "Brunswik Number," based on cognitive continuum theory, could provide a similar aid for social psychologists. They leave the development of this index for others. We hope readers will be inspired by these ideas and continue Hammond's legacy.

Thomas R. Stewart
Denver, Colorado
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Confronting Inductive Inference (at last):
Concepts from Aeronautical Engineering Can Lead to Advances in Social Psychology

Kenneth R. Hammond & Zoë R. Lang

Both social psychology and aeronautical engineering got started roughly around the same time — the late 1800s (Baals & Corliss, 1981; Farr, 1996). What is so different between the two fields now? Aeronautical engineering has become a huge success, while social psychology is admittedly a failure. Why is that? Can we learn from that? Yes! And that is what this paper intends to demonstrate about the inductive inference problem regarding critical environmental variables that are common to both fields.

Aeronautical engineers in attempting to design modern aircrafts could not test the functionality of their designs on the ground under the conditions in which they were expected to fly; these engineers were tasked with ensuring the aircrafts to be competent to fly at altitude, upwards of thoughts of feet in the air. In short, aeronautical engineers had to make an *inductive inference* of a substantial nature, one that would allow them to infer the behavior of an airplane thousand of feet in the air from the behavior of an airplane built at the surface of the Earth. The efforts of aeronautical engineers were enhanced considerably, however, by the use of the Wind Tunnel. The wind tunnel offers an experimental opportunity to simulate flight conditions above the Earth and test scale models of aircraft components thus providing the context and circumstances necessary for inductive inference to parallel the experiments that psychologists would conduct allowing them — they hoped — to infer behavior outside the laboratory. Nevertheless, whatever they discovered about the behaviors of objects in the wind tunnel, they would face the problem of inductive inference to the flights conditions the aircrafts would actually encounter.

The problem of inductive inference.

Philosophers have long engaged in the practice of explaining and describing the need for understanding the inductive inference process, and the difficulties thereof, all of which come down to the fact they are a) uncertain, and b) entangled with one another. The one class of philosophers that have stood aside from analyzing the process of induction are experimental psychologists who have continued to glaze over the problem and therefore have gone on to make unjustified inductive inference a mark of their trade. But if experimental psychologists can ignore the problem (as in the case of North and Fiske (2013)), experimental social psychologists cannot use this easy solution. That is because the essence of social psychology lies in the application of psychological theory to social conditions, such as the interaction with other persons and the drawing of inferences about the behavior of other persons. And that brings us to the essential thought processes involved in inductive inference that requires when we make an inductive inference from the laboratory to the conditions of our experiment we specify the conditions to which the experimental results apply. Prior to space exploration physicists did not know about the change in conditions of their generalizations until they actually found different conditions to exist. In psychology, we have to ask ourselves just what conditions we anticipate will be the locus of our results. Thus, for psychologists, the problem is much more complicated. That is, physicists have only to find the difference between the functions of physical laws on Earth and various other planets (such as Mars); whereas psychologists and other social scientists will have to exercise their imagination without any guidance whatsoever.

But the inductive inference from conditions in the experiments to conditions outside the experiments is given very little consideration in psychology today. It is taken for granted that experiments are valuable, that experiments give us the information we need because it is traditional to manipulate one variable and control for the rest, a procedure that allows one to infer that something caused something else. What researchers fail to see is that causality is not the only problem. One other problem is in generalizing from the laboratory environment, in which you control all but one variable, to the world outside your experiment where there are numerous uncontrollable variables. For if you give up control of the variables, you lose control of rationality, a topic to which we now turn.

Egon Brunswik's criticism of the conventional design of experiments in psychology was not restricted to merely the arrangement of variables in an experiment. He saw that experiments in psychology have focused primarily on studying two major topics -- causality and generality. The emphasis on causality led to deemphasizing the generalization of results of experiments to the external world. Indeed, generalization from experiments did not come under critical modern examination until Brunswik introduced the topic in "Perception and the Representative Design of Experiments" (1956). However, Brunswik's book, with its emphasis on the distinction between inductive and deductive generalization from experiments in psychology, has been steadfastly ignored, and continues to be ignored (with the exception of the work of the members of the Brunswik Society; see for example Hammond 2001). This limitation has been particularly injurious to clinical psychology.

The standard or conventional design of experiments —the rule of one variable— was created to isolate a single variable, and thus allow a conclusion about cause and effect, and it has been used for this purpose for generations. More variables were added within the framework of what has been called Analysis of Variance (ANOVA) to combat the obvious shortcomings of single variable research but always with the restriction that each independent variable added was to be orthogonal to every other variable. ("Orthogonal" meaning that all variables were assumed to be linear and independent of one another, unless specifically arranged to be otherwise).

Although this conventional experimental design has been directed toward the study of causality, no specific design has been created for the purpose of generalizing results from the experiment to other specified (e.g. intercorrelated) circumstances. Generalizations from an ANOVA design, if any were attempted, were highly specific to the purposes of the research and the logic involved was examined accordingly. Recently, however, in the sub-discipline of social psychology, some research projects have attempted to generalize the results of the standard (orthogonal) design of experiments to actual social circumstances—non-linear and non-independent— outside the laboratory, and have received considerable attention for doing so despite their flaws (e.g., North and Fiske, 2013).

We turn now to a variety of examples. The first of which illustrates how psychologists of high status ignore the problem of inductive inference from experimental conditions, the next two experiments that have begun to move their design in a representative direction but have fallen short, and the last of which illustrates how the problem is solved by a change in experimental design and theory.

Examples.

Michael North and Susan Fiske examined how a person's attitude [perception] shifts due to the age and behavior of others (2013). Their research proposes to learn of the effect of age in judgments relating to societal resources. North and Fiske conducted six studies using vignette-based trait ratings and simulated interactions. Each experiment followed a 3 (older/middle-aged/younger target) x 2 (violating/adhering to prescriptive expectations) design (2013) in which study participants rated the target individuals based on three fixed scenarios. The three scenarios included participants rating the target individual based on neutral background information of the target with some manipulation. The first scenario had participants rate whether the target was generous or stingy with their money (person described as "financially comfortable"), the second about whether the target should "stubbornly" go through with a resource intense medical procedure or forgo it, and the third scenario judged targets based on their response to music artists as either current or "oldies." However, North and Fiske failed to manipulate the objects- they ignored the problem of the number of objects (object N) in their design— in their experiments to allow for generalizability of the results. Their failure to do so stems from having only a single individual object (N =1) in each of their three age groups (younger/middle aged/older) of which no other manipulations are made, i.e all variables are orthogonal. The lack of variation in the design minimizes the number of objects such that the number is not large enough to yield credible results, much less generalizations. The problem with their method is they did not recognize they were making an inductive inference over age groups, and as a consequence, they did not criticize the nature of their inference. In any inference of this sort that involves the collection of individuals, the number of individuals in each category will be critical.

The generalizations offered by North and Fiske were unjustified because they used only one vignette or simulation interaction per fixed scenario. That design produced results that carried no potential for generalizing to situations outside of the vignettes and simulations provided in the laboratory. Yet the result were accepted by the New York Times and given prominence on the front page of the Business section and thus widely circulated despite the lack of support for generalization.

Public acceptance of these erroneous conclusions offers a glaring example of a flawed inductive inference that ignores the rule that one can only generalize only in so far as they have sampled. This applies to both the input and output of an experiment; without variation one cannot make an inductive inference.

A step in the right direction was taken by two studies (Correll, Park, Judd, & Wittenbrink, 2002, and James, Vila, & Daratha, 2013) both of which included recognition of the need to sample objects respectively. There were 20 different images included as the object N in the Correll et. al study and James et. al defined their objects as 60 simulated scenarios that justified their inferences. Both studies used technology to make use of virtual situational testing that allowed for a sufficient object N value to justify the generalizations made within each experiment, especially since both Correll et. al and James et. al also included context that was lacking from previous studies. By increasing the value of N to be greater than 1, Correll et. al and James et. al have moved their respective experimental designs to be more representative than the study conducted by North and Fiske. Though the experiments of Correll and James have begun to move away from the conventional experimental design, their systematic treatment leaves more to be desired in terms of treating the sampling of objects in a systematic manner.

Having illustrated the current flawed approach to inductive inference taken by North and Fiske and the advances made by Correll et. al and James et. al, we turn now to a uniquely positive example. The best current illustration of the importance of the role of inductive inference and influence of modern technology on the maintenance of health is that of Robert Kaplan and Arthur Stone (2013). These authors not only provide numerous examples of the use of modern technology but they make use of the work of Egon Brunswik to provide a solid basis for their inductive inferences in their 2013 Annual Review of Psychology chapter. They show how Brunswik recognized the weakness of current methodology in dealing with inductive inference and they lay out the basis for a new psychology built upon that recognition. Regrettably, however, their work has been almost entirely ignored by current psychology as the above examples illustrate. Kaplan and Stone do not merely cite examples of use of modern technology in inductive inferences but they build a firm foundation for their work to the application of Brunswik's innovations, particularly the representative design of experiments.

Brunswik's criticism of the design of experiments in psychology was not restricted to merely the arrangement of variables in an experiment. The authors make note that often the outcomes of interests [in a study] are determined by a number of environmental and contextual factors, such that what happens in the laboratory setting may not be representative of what happens in more complex non-laboratory environments (2013). The important point to be observed about the given examples is that the population to which the generalization is intended is made perfectly clear. And although that sounds like mere common sense, it is in fact a rarity. Kaplan and Stone discuss that often the methodology of experiments suffer because the systematic design is too narrow and the design lacks connection to what happens outside of the laboratory (2013).

The authors stress that laboratories and clinics are such highly controlled environments that the most research can do is establish cause-effect associations within that controlled environment (2013). These associations are "artificial" especially when the "psychological process is affected by environmental context" (2013). As a solution to combat the issue of artificial results and generalizations being made, Kaplan and Stone suggest employing current technologies to better conduct experiments outside of the laboratory; what they label as "moving the laboratory to the real world" (2013).

Kaplan and Stone note that moving the capabilities of the laboratory into the real world requires use of modern technology, especially within the field of mobile and wireless health (also known as: "mHealth"). Modern and portable technologies allow for "bringing the laboratory and clinic environment into natural environments" (2013). For example, blood pressure assessments taken over a 24-hour monitoring period versus an office reading can differ substantially because blood pressure varies over the course of time, i.e. circadian rhythms (2013). Remote monitoring and sensing can allow researchers to recruit and follow patients without the need and associated costs of transporting them to a research of healthcare facility" (2013). Blood pressure measurements can predict and make indications about individuals' health (Mayo Clinic, 2014).

Multiple measurements of one persons' blood pressure allows for healthcare professionals to integrate all the collected data to improve the quality of the health assessment in real time and augment the design of research, experiments and treatment.

The goal of Kaplan and Stone's work is to encourage continuous monitoring and permit data capture in a representative sample of environments (2013), such that research can begin to focus on more representative and generalizable results. "…developments and advances in our ability to study outside the laboratory have made the notion of representative design and sampling a practical reality" (2013).

The Wind Tunnel and Reynolds Number.

Research using the Wind Tunnel enabled aeronautical engineers to develop and apply a concept known as the Reynolds Number that has been a huge advance for engineers. An advance because Reynolds numbers define various environmental conditions of a fluid in motion ranging from calm to turbulent conditions. The definition of Reynolds number is:

$$Re = \rho VL/\mu$$

Where ρ is the density at the altitude at which the aircraft flies, V is its speed, L is a characteristic length of the aircraft and μ is the dynamic viscosity at the altitude at which the aircraft flies (Reynolds 1883; Rott, 1990). The Reynolds Number is the ratio of inertial forces to viscous forces; it includes four readily identifiable parameters that provide a readily identifiable state of a fluid motion). This ability to identify the state of the flow is important because it provides a target for making the inductive inference from the observed situation to the predicted situation; having a definite target allows us to observe the accuracy of the inference. Though wind tunnels could not accommodate a full-sized aircraft, scale models of wings and aircraft components were tested in the tunnel that provided a fraction of the flight value that an engineer could then use to estimate the behavior of the aircraft components at a full scale. This is precisely the circumstance that psychologists need but do not have. For when psychologists make an inference for what should occur in "real world" from the experimental situation they have no precise, standard means of identifying the predicted situation. And therefore have no means for testing the accuracy of the inference. As a result, the inferences drawn from social psychological experiments remain untested and do not achieve the status of a scientific inference. If the psychologists had the equivalent of a Reynolds Number (which the engineers enjoy) they would be in a similar situation to that of the engineers and thus be able to make make accurate predications in natural, complex environmental conditions. To reach the equivalent of a Reynolds Number, we will have to evoke the theory of a Cognitive Continuum.

Cognitive Continuum and Task Continuum Indicies.

Discussing the cognitive activity of an organism requires a theoretical organization that provides us with the terminology we need. In our case it is clear the terminology we need will involve intuition and analysis. Once we recognize the physical, environmental properties of a situation we are required to have a theory that will describe and/or explain the psychological (cognitive) activity demanded by the problem.

We begin with the proposition that the cognitive activity in which we are interested lies on a continuum between intuition and analysis. Analysis and intuition are fundamental starting points for any theory of cognition. Analysis, of course, refers to the explicit properties of logical cognitive activity, while intuition begins with the acknowledgement that our thoughts and arguments often begin with unjustified, and usually implicit premises. (The relation between these two concepts has not been as clearly delineated as we would have liked but the introduction of these into psychology is treated in detail in *Human Judgment and Social Policy (*Hammond 1996; see especially chapter 3)).

On the other hand, analysis and intuition have been suggested to have a dichotomous relationship (Kahneman, 2011) in which two systems of thinking exist, one fast and one slow. As put forth by Daniel Kahneman in his book, *Thinking Fast and Slow*, System 1 accounts for “fast” thinking that is automatic and intuitive, whereas System 2 is dominated by reason and analysis that requires “slower” cognitive processes. Analysis requires the subject to be explicit about the properties of cognition and how they are related and claims that the explicit logical connections between its subconcepts is its greatest strength, and is critical of any approach that does not achieve this kind of defensible clarity. Intuition on the other hand makes no such claim but defends its value by its creativity and therefore does not require any explication of its properties. From these distinct definitions, Kahneman argues that processing information takes longer than feeling and that ultimately one system of cognitive activity, System 1, prevails over the other, System 2, in decision making — a conclusion that the present authors challenge with the concept of *quasi-rationality,* which says that both intuition and analysis can play a role and have an effect in every single decision.

The distinction between Kahneman’s dichotomy and our continuum may seem trivial, but it is not. The significance of the concept of a continuum is explored by Edward O. Wilson in his fascinating book “The Meaning of Human Existence” (2014) and is worth contemplating; “The exploration of continua allows humanity to measure the dimensions of the real cosmos, from the infinite ranges of size, distance, and quantity, in which we and our little planet exist. Scientific enterprise suggests where to look for previously unexpected phenomena, and how to perceive the whole of reality by a measurable webwork of cause-and-effect explanation. By knowing the position of each phenomenon in the relevant continua— relevant continua in ordinary parlance being the variable of each system— we have learned the chemistry of the surface of Mars; we know approximately how and when the first tetrapods crawled out of ponds onto the land; we can predict conditions in both the infinitesimal and near-infinite by the unified theory of physics; and we can watch blood flow and nerve cells in the human brain light up during conscious thought. In time, likely no more than several decades, we will be able to explain the dark matter of the Universe, the origin of life on Earth, and the physical basis of human consciousness during changes of mood and thought. The invisible is seen, the vanishingly small weight. So, what has this explosive growth of scientific knowledge to do with the humanities. *Everything*" (2014).

The breakdown of the dichotomy, as a current example, has occurred with sexuality. An individual's sexuality has often been defined as either heterosexual or homosexual. Recently, however, that either/or dichotomy of sexuality has weakened and the concept of sexuality is now also on a continuum. In other words the Cognitive Continuum parallels the sexual continuum, and all the other continua mentioned by E.O. Wilson.

The main importance of the concept of a "cognitive continuum" is that it allows for cognitive activity that shares the properties of both intuition and analysis. These properties allow any particular type of cognitive activity to be described as "quasi-rational" (somewhere in the middle of the continuum). It is a premise of this theory, Cognitive Continuum Theory, that the vast majority of our judgments follow from quasi-rational cognition, that is, cognition that is, neither fully rational nor fully intuitive. It is this quasi-rationality that explains the persistence of arguments. Were arguments to be based on fully analytical material they could be settled in one fashion or another, as is the case in mathematics. For example, few would argue against the notion that 2 + 2 = 4 because the reasoning is explicit. The open-ended character of intuition-based concepts is what encourages an argument to continue because reasoning founded in intuition lacks defensibility. At the same time that open-ended-ness makes possible compromises that could not be achieved with the use of fully analytical or fully intuitive concepts. The presence of a continuum makes it possible for compromise between the two poles to be achieved more readily, whereas the use of two distinct systems, as in a dichotomous relationship (Kahneman, 2011), will require relinquishment of some properties, such as certain scientific values, and rejection of others.

The Cognitive Continuum thus allows for combinations of intuition and analysis to be recognized and studied. These combinations are based on the multiple fallible indicators in a specific situation, and the change in their use will follow the course of a discussion. One who sees this is, Sendhil Mullainathan, a professor of economics at Harvard University, who reviews various discrimination studies involving multiple fallible indicators and summarizes the major findings of some of these studies in the article (New York Times (Sunday, 4 January 2015)). He suggests, "…hopefully the sheer depth of these findings impresses you, as it did me" (page 6). Mullainathan cites the work of Daniel Kahneman on thinking both fast and slow when making judgments. Although Kahneman's work is based directly on the idea of a Cognitive Continuum, he does not mention this. Mullainathan acknowledges that "hundreds of other factors" other than the speed of thinking affect our judgments, and writes that often when making "slower deliberate judgments" we would use some of these other factors.. but "many factors escape our consciousness".

Cognitive Continuum theory endeavors to integrate all of these fallible factors into a single dimension and thus allows a researcher to identify the point on the continuum that a given person is using in his or her thinking. As Mullainathan points out "this kind of discrimination [implicit bias] crisply articulated in a 1995 article by Mahzarin Banaji of Harvard and Anthony Greenwald of the University of Washington has been studied by dozen of researchers who have documented implicit bias outside of our awareness". Mullainathan thus carries a psychological theory—Cognitive Continuum theory— to social science and the public. The value of this step lies in its ability to identify and thus show how a variety of multiple fallible indicators are used in the case of an individual judgment, and where these indicators place a person's judgment on the continuum. But the Cognitive Continuum needs the equivalent of the Reynolds number.

Prior to devising an equivalent psychological numerical representation of the Reynolds Number, another aspect of Cognitive Continuum Theory is necessary to include. The Task Continuum Index is an essential component of cognitive theory, the index measures information relevant to the characteristics of task conditions and properties in a judgment situation. The TCI was created from eight task characteristics predicted by the cognitive continuum theory to induce cognition at different locations on the continuum based on if characteristics were either depth (covert) or surface (overt) cues (Hammond, Hamm, Grassier & Pearson, 1987). Task properties, which must be specified and restricted by situation, are justified by their presence within naturally occurring tasks, increasing the likelihood that ecological generalizability to environmental systems is achieved (Hammond, Hamm, Grassia, & Pearson, 1987). To quantify a judgment in a single number, the task continuum and cognitive continuum indices must both be examined. Comparison of the TCI and CCI may reveal a low score on the TCI, that may be compensated by a high score on the CCI, as suggested by Brunswik as representing intersubstitutionability of cognitive activities and task properties as they relate to the general theory of probabilistic function (Hammond, Hamm, Grassier & Pearson, 1987).

Brunswik Number.

As noted above, aeronautical engineers faced a similar problem of integrating two forces, the inertial and the viscous force, in a single equation. Our task is similar. We need to integrate the analytical and intuitive parameters of cognition in a single number or index for social psychology. The Reynolds Number is the product of the combination of two physical forces, our combination of the intuitive and analytical parameters (which we shall call the "Brunswik Number") can be represented in terms of a number reflecting the ratio between the parameters. Thus, for example, B = intuitive \ analytical parameters. The Reynolds Number enabled the environmental aspects of making a specific aeronautical judgment to be present when simulating experiments, such as the Brunswik Number must not only rely on cognitive properties but also include the task properties of the environment in which a judgment is present. To account for task conditions the definition of the Brunswik Number would compare the parameters from both the CCI and TCI when calculating the numerical representation of a judgment in Cognitive Continuum Theory.

Notice the difference in what this approach produces compared to what the Kahneman "bias" approach produces. This approach tells us *how* the subject is thinking about the dimensions of a given problem, whereas the Kahneman approach tells us about the consequent bias that is the difference reflected in the subject's judgment and some theoretically derived correct judgment. Each has its advantages. It may be useful at any given time to be able to denote a bias; on the other hand it may useful at any time to understand whether a subject is engaged in intuitive and/or quasi-rational and/or analytical cognition.

In 1996, the following table, *Table 1,* was presented in *Human Judgment and Social Policy,* which describes the properties of intuition and analysis, and although 20 years have passed, it is still sufficiently appropriate that it be included here.

Table 1. Properties of intuition and analysis; from Human Judgment and Social Policy, 1996.

	Intuition	**Analysis**
Cognitive Control	Low	High
Awareness of cognitive activity	Low	High
Amount of shift across indicators	High	Low
Speed of cognitive activity	High	Low
Memory	Raw data or events stored	Complex principles stored
Metaphors used	Pictorial	Verbal, quantitative

The properties of the intuition and analysis described in the table were derived and discovered through experimentation.

For example, we may describe an individual's judgment as intuitive if we notice that it is made rapidly and without reference to an analytical framework such as algebra. Or we may decide an individual is making an analytic judgment using a purely mathematical framework. In any given experimental situation, the experimenter will have to observe first the amount of time it takes the subject to express his or her judgment, secondly the rapidity and ease with which a justification is presented by the subject, and thirdly the nature of the justification (rigorous or tendentious). For instance, in judgment situations in which the subject is required to reach a judgment quickly and with little thought, the properties indicated above (Table 1) have been frequently observed with regards to intuitive thinking and the opposite is true with respect to analytical judgments.

The specific numerical representative of a judgment as a Brunswik Number on the Cognitive Continuum Index will have to be made by an experienced cognitive scientist. The cognitive scientist will also need to specify the Brunswik Number on the Task Continuum Index to recognize the importance of environmental factors when generalizing from one judgment situation to another. "..maximizing accuracy in any judgment task will require that the expert carefully attend to both task conditions and the cognitive activities to be applied to them" (Hammond, Hamm, Grassia, & Pearson, 1987).

In short, we do not have the methodological sophistication at present to provide the reader or anyone else with a rigorous interpretation of a judgment into a single number. The accuracy of that translation will have to be substantiated by the user of the Brunswik Number. However as the Wind Tunnel is a perfect example of the experimental device needed by aeronautics, the Brunswik Number would be an experimental design concept within the framework of representative design.

Conclusion.

This paper proposes a shift in methodology from that normally used in social psychology to that used in physical sciences, for example aeronautical engineering. Aeronautical engineers faced up to their major problem, that of representing altitude flight conditions in land-based experiments, at the beginning of their work. They discovered the Wind Tunnel as the main device for implementing this type of representation. Consequently, we have only single wing aircrafts and multi-winged aircraft have all but disappeared. Psychologists have not been so fortunate in their efforts to represent external conditions; they have not been able to find a single device that would be so useful in representing a wide range of conditions specific to their purposes. Even the problem of representation of conditions has not been generally *acknowledged*. Egon Brunswik's work in "Psychology and the Representative Design of Experiments in Perception"(1956) has been almost completely ignored, if not greeted with hostility. In this paper we have attempted to show the critical problem of representation of conditions within experimentation and how it is resolved by the use of the statistical method, exactly as it has been shown to be the case on the subject side of the experiment. Numerous examples of the role of representation have been given in "The Essential Brunswik: Beginnings, Explications, Applications" (Hammond & Stewart 2001).

In this paper, we have focused on high status experiments in prestigious departments presenting flawed interpretations that were given great publicity and little criticism (North & Fiske 2013). In addition we showed that Correll et. al (2002) and James et. al (2013) have taken steps in the direction of representation and generalizability. Kaplan and Stone, however, have shown how representation of conditions can open a new dimension of research in clinical psychology. By employing technology that can function outside the traditional bounds of the laboratory setting but remain within the scope of the experimental design, data can be collected and observed within multiple environments. Kaplan and Stone have argued that focusing on representation can move the laboratory to the real world and permit better experimental design and sampling procedures (2013).

In addition to Kaplan and Stone's progressive use of representative design, we have reintroduced a theoretical approach that is related to this form of experimentation, namely Cognitive Continuum Theory. This theory is focused on identifying the *form* of cognitive activity that is applied in a particular case. In accordance with that theory we introduce the Brunswik Number (in connection to the Reynolds Number used in fluid dynamics in physical science) that would allow for representative generalizations to be made from the laboratory setting to the social circumstances. Though the nature of how to derive the Brunswik Number has not been outlined in this paper, we urge the field of social psychology to embrace the conceptual nature of the Reynolds Number and Brunswik Number to integrate intuitive and analytical cognition. By applying the theory of the Cognitive Continuum, the Brunswik Number will allow for researchers to ascertain how an individuals' judgments are being made, and from there be able to generalize from various sets of environmental circumstances by integrating both analytical and intuitive cognitive parameters in the analysis of experimental design and results. A representative design that would insist on organization of independent variables, on a wide variation of independent variables, and representing the wide circumstances and properties of social life is what is needed. We need validation across experiments and experimental design, not within, but that will require a whole new approach to social psychology.

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