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Is Random Error Useful for Developmental Psychology?

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Abstract: Within psychology, quantitative methods have been pushed as the mark of objectivity and the scientific pursuit of general knowledge. However, all forms of data are representations of phenomena and are prototypically cultural products. That is, they are meaningful signs through which humans understand, manage, and transform the immediate here-and-now situation (i.e., phenomena) for particular purposes (e.g., knowledge construction). Data, like all representations, are laden with implicit assumptions given by the perspective from which the act of representation is undertaken. It is crucial that data, analysis, and theory are consistent with one another. This is especially true in the case of developmental science, which holds very specific assumptions. Developmental assumptions make variability the center of phenomena, yet the statistical focus on error and randomness eliminate that concern. Utilizing the notion of random error entails an assumption as to the inherent stability of its referent while development is a dynamic process leading to the emergence of novelty. Institutionalized reliance on any one sanctioned set of methods or forms of data ignores the issue of the adequacy of the data in representing the underlying phenomena. The possibility of constructing general knowledge while maintaining the full variability inherent in developmental phenomena is discussed.

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1. Data as Representations and Methodological Consistency

The distinction between "qualitative" and "quantitative" methods has been the site of an unending—and probably unnecessary and unproductive—argument, much of which has hinged upon the notion of "objectivity". Despite the social history of and pressures toward quantification as *the* mark of objectivity (DASTON, 1992; GIGERENZER, 1987; GIGERENZER et al., 1989; PORTER, 1992, 1994, 1995), such a claim clearly cannot be sustained. All forms of data—from numbers to interview transcripts to paintings or drum beatings—are taken by the researcher as representations of the phenomenon of interest and are analyzed in some way as part of the process of investigation (VALSINER, 2000). All data-gathering (i.e., phenomena-describing) instruments elicit the transformation of phenomena into analyzable data (description, representation) by a kind of "filtration" through the terministic screens (cf. BURKE, 1966) implicit in the instruments themselves. [1]

In other words, every mode of data construction entails a terminology in which a particular observation (description) of phenomena is made. In *Language as symbolic action*, BURKE notes that "[e]ven if any given terminology is a *reflection* of reality, by its very nature as a terminology it must be a *selection* of reality; and to this extent it must function as a *deflection* of reality" (BURKE, 1966, p.45; original emphases). What makes BURKE's formulation different from the standard notion of data as a "simplification and therefore distortion (but in essence true anyway)" is that he highlights the idea that the process of representation is inherently "suasive". That is, even the most unemotional and apparently "objective" description or representation necessarily presents some version of the world and embodies an implicit argument against other possible ways of viewing reality. From this angle, data do not simply reflect reality. They serve the function of directing attention and, even further:

> "[N]ot only does the nature of our terms affect the nature of our observations, in the sense that the terms direct the attention to one field rather than to another. Also, *many of the 'observations' are but implications of the particular terminology in terms of which the observations are made*. ... [M]uch that we take as observations about "reality" may be but the spinning out of possibilities implicit in our particular choice of terms" (BURKE, 1966, p.46). [2]

Following from this, there is no reason to privilege any form of representation over any other as either more or less "objective". The notion that "that which is quantified is independent from the particular research instrument" does not hold. It fails in exactly the same way as does the assertion "My interview is filled with data that are independent of the particular questions in my protocol." The safety offered by reliance on one set of institutionally sanctioned research methods or another is false. The fight over "objectivity of the data" takes place on the basis of the cultural process of creating a label (i.e., "objectivity") which gives rise to a previously non-existent field within which the objective/non-objective contrast organizes human action toward the immediately encountered world. [3]

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However, rhetorical positioning of oneself on one or another side of the objective/ non-objective distinction does not solve problems for a science. The issue lies in the fleshing out of adequate relations between the components of the "*cycle of methodology*", which includes the phenomena, the kind of question being asked, the researcher's own theoretical constructions and intuitive encounters with the phenomenon, as well as methods of data analysis (BRANCO & VALSINER, 1997). Any effort to move this kind of case-by-case examination of the research setting to the level of broad statements about what kinds of methods or data-representations are more or less "objective," "good," or "scientific" is only an effort at either conversion or self-defense and does not necessarily contribute to the imaginative, productive forward movement of a science. In this paper, I will examine the idea of error and, in particular, the notion of "random error" vis-à-vis the concept of development with an eye toward the question of whether or not any study of development can yield useful knowledge (defined as consistency within the methodology cycle) about development through the use of statistical methods which rely on random error. The concept of development is particularly relevant to cultural psychology given the latter's focus on the emergence of novelty within the individual's efforts to relate to (i.e., make sense of, transform, deal with) the here-and-now setting by way of the construction and use of signs. [4]

2. Campaigning to Become a Science: The "Error" Platform

The push toward quantification was made in the effort to have psychology recognized as a natural science along the lines of classical physics. Psychology, like any natural science in the classical mold, is involved in the quest for (certain) knowledge. Within that mold, the ideal of knowledge takes the form of universally applicable, immutable, causal laws that would allow the "prediction and control" of each and every individual subject. Perhaps ironically, that quest has necessitated the build-up of the notion of "error" in at least two complementary ways—each of which matches well with an ideal of the traditional natural sciences after which experimental psychology modeled itself. [5]

2.1 Determinism and error

The ideal of determinism can be summarized with the phrase "if we could measure everything ...". Pierre Simon Marquis de LAPLACE (1749-1827) is commonly taken as the figurehead of determinism. He examined the orbits of planets using NEWTON's laws of gravitation. The fact that future positions of planets are predictable and past positions calculable through these laws provided an ideal model for all of human science. The model idealized relatively simple, static "truths" or laws that explain a variety of phenomena, both past and present. In a deterministic world, every state contains a representation of its complete past and its complete future (VAN GEERT, 1997, p.121). [6]

This model entails certain assumptions. LAPLACE (and his demon—who had access to all of those "truths") assume the stability of causal essences and of that which is to be explained (e.g., X, which is never anything but X, is caused by A, B, and C, which are never anything other than A, B, and C; A,B,C, –**>** for ever and ever). Given such qualitatively stable essences (which are capable of quantitative variation; i.e., they are *variables*) on both sides of the causal arrow, the task of science was to amass enough variables on the "cause" side to explain all of what the arrow pointed to. [7]

Since the institutionalization of silence regarding the internal inconsistencies of what has come to be known as "the statistical method" (cf. GIGERENZER et al., 1989, for a full review), this conception often takes the form of the statistical notion of "explained variance". Explained variance is basically defined as the answer to the question: "How much of the present variation in the dependent variable is equal to preceding variation in the independent variable(s)?" This, of course, leaves the issue of unexplained variance. There are at least two possible ways of characterizing and dealing with un-"explained" variance. On one hand, the subject matter itself could be considered to be probabilistic. On the other hand, the need for probability could be taken as a marker of the ignorance of mortal humans. The former is deeply threatening to the mission of deterministic takes on science. Probability was not acceptable on the level of theory-building within the deterministic framework, where naming and arranging variables on the left side of the causal arrow is the name of the game and the causal arrow itself was intended to be omnipotent. [8]

Any failure for a strict, 1-to-1 relation to hold was to be relegated to the "error variance" term. From this angle, "error variance" is a catch-all term for several possible imperfections in the research situation. First and foremost, unexplained variance is to be blamed on the human researcher's non-demonic ignorance as to the true workings of reality. This can be seen as an extension of the Enlightenment belief in constant causal processes that are identical across time, place, and individual. [9]

There are other practical limitations to conducting research, which may have many consequences. For example, independent variables may not have been properly manipulated, leading to unexpected results given the presumed experimental manipulation, or errors may have been made in measurement. Most importantly, other variables—whose effects on the dependent variable may be insignificant but nevertheless real—may have gone uncontrolled. This reflects both the insufficiency of the researcher's theoretical model (after all, variables substitute for theories in this framework) and the inescapable intricacies of the experimental situation. [10]

2.2 Eliminating error through prototyping

As opposed to the first look at the notion of error, which focused on the inadequacy of humans in the face of an unfathomably intricate design, the development of mathematical notions of error was taken by some to grant humans a view to at least some aspects of divine design. As I mentioned before, the deterministic framework assumes the inherent stability of both causal essences and the objects of explanation. It is a picture of a clockwork world into which human beings working as researchers attempt to peek through clouded

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lenses. Probability was not allowable on the level of theory within the deterministic framework and, therefore, faulty observations and imperfections in the objects of interest must be concealing the truth. [11]

However, if causal laws are universal, how are they to be discovered, given the inter- and intraindividual variability that distort our picture of the reality given to us by those laws? Inter-individual variability can be defined as the difference between the performances of different individuals on a single task. Inter-individual variability is usually emphasized over its counterpart, intra-individual variability, which can be thought of as "relatively short-term changes that are construed as more or less reversible and that occur more rapidly than the intraindividual change [i.e., development—S.S]" (NESSELROADE, 1991, p.215). LAPLACE's quest was for an adequate representation of the essence of reality in the midst of observable (and seemingly incomprehensible) variability. In that quest, he stressed the importance of statistical regularities—especially the average of repeated observations—since those were, for him, the true indications of constant causes in nature (JOHNSTON, 1999). Once calculated, the mean ascended to the status of the "true value" of the object of measurement (which, for LAPLACE, was mostly the position of stars through substandard telescopes). Deviations from the "golden mean" were considered "errors". LAPLACE adapted Abraham DE MOIVRE's "normal curve" (which was first discovered in 1733 the context of games of chance—see GOERTZEL & FLASHING, 1981) to his interest in errors of observation and noted that his errors matched that template. Errors, for LAPLACE, were not caused by chance, but by specific reasons that could be discovered by careful scrutiny of both the object of interest and the instruments of measurement. [12]

The growing popularity of statistical studies and uses of the average (and other mathematical forms of eliminating the individual) fed into QUETELET's efforts to construct a "social physics," which appeared in 1831 (GIGERENZER et al, 1989, p.41). QUETELET's social physics was built up around the concept of the "average man," who was an abstraction based on the average scores of many unrelated tests and measures. The importance of the non-existent average man for social physics was impossible to overestimate—and note the explicit distancing of social physics from concerns of individual development:

> "If one seeks to establish ... the basis of a social physics, it is he [the average man—S.S.] whom one should consider, without disturbing oneself with particular cases or anomalies, and without studying whether some individual can undergo a greater or lesser development in one of his faculties." (QUETELET, 1835, vol.1, pp. 21-22) [13]

By 1844, QUETELET determined that human variation was governed by the error law (i.e., fit under the normal curve) and used this to prove that the average was really the (proto)type of nature in exactly the same way that the mean of astronomical observations reveals the (approximately) true position of a star. In both cases, variations around the true mean were found to occur in a regular pattern—now known as the bell curve or normal distribution. Each individual, he believed, is an imperfect, error-laden replica of the average man. Although the

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potential of the metaphor to offer an overarching understanding of the natural world must have been extremely appealing for QUETELET, who was working on both descriptive astronomy and issues of human psychology, it is clear that he was confounding two definitely separate tasks. On one hand, humans indeed make errors in their estimation of the external world (e.g., planets which really did have a "true position"). On the other hand, humans themselves were assumed to have a metaphorical "true position". He was seeking the one "true position" of all of humankind. That could be analogous to him looking for the one "true position" of all celestial bodies at once (while making relatively unreliable observations of relatively few planets). This cross-level, cross-domain transposition from particular objects to the general class of observers of those objects yielded the "average person". This kind of transposition of evaluations of an individual's actions outward (e.g., toward some object such as a Rorshach test) into supposed characteristics which are taken to hold for all potential actors is still widespread. For example, consider the diagnosis of an individual responding to a Rorshach test (i.e., "If this kind of response is made for inkblot X, the client has characteristic Z"). [14]

GAUSS and GALTON—1795 and 1888, respectively—each made more systematic studies of the normal curve of error, although with opposite intentions. GAUSS sought to get rid of error as perturbations of a system governed by constant causes while GALTON sought to preserve and study variability, as seen in his development of the concept of "statistical unit," which is now known as the standard deviation. Although the transition from the dismissal of error as undesirable to its systematic study is usually cited as the point of transition between classical and modern statistical theories (JOHNSTON, 1999), the notion of what exactly error is (as opposed to its nature, causes, and theological implications) remains and has been carried over into contemporary statistical procedures. Error is a deviation from a true score (WOLMAN, 1989; ENGLISH & ENGLISH, 1958). This is obviously different from an error of judgment, as is the case in Type I (alpha) or Type II (beta) error. James McKeen CATTELL, writing in James Mark BALDWIN's *Dictionary of philosophy and psychology*, stated that "the departures of the separate measures form the true value are called errors ..." (BALDWIN, 1901, p.340). For almost 200 years, error has been conceived of as the variance of any particular measure vis-à-vis aggregate of such objects or measurements. [15]

3. The Notion of Random Error

When we consider these two views of error together, the concept of random error becomes apparent. In BALDWIN's dictionary, CATTELL wrote, "the theory of errors ... is based on the assumption that each error is the result of a great number of small causes independent of each other and equally likely to make the measurement too large or too small" (BALDWIN, 1901, p.340). The term "random" has become attached to the idea of invisible "small causes" which have the following characteristics: 1) are beyond our knowledge (i.e., ignorance a la LAPLACE) and/or interest and 2) have the effect of interrupting the endless replication of the mean. [16]

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To summarize, error is conceptualized as variation from a mean score, magnitude, or value that is taken to represent the true state of the object under investigation. Such variations are "random" because they are caused by "small" (or "weak," "accidental") causes that are beyond our knowledge and effect the measurement in an unpredictable way. These errors occur in a specific probability distribution (i.e., the normal distribution), as dictated by the law of errors. Thus, random error can be defined as:

> "Mistakes in measurement that are the result of unknown causes and therefore *cannot either be controlled or predicted*. The mean of a series of measurements is taken to be the true value, and an *accidental error is the departure from this mean. Accidental errors are considered to be due to random or chance factors*." (WOLMAN, 1989, p.118; emphasis added) [17]

ENGLISH and ENGLISH offer the following:

> "That part of the variability of a set of observations or scores that can be *attributed to chance*. It will depart from the true value as much and as often in one direction as the other, so that the sum of chance errors for a large number of cases approaches zero." (ENGLISH & ENGLISH, 1958, p.187) [18]

Contemporary statistical textbooks typically define random error as "the combined effects (on the scores of individual subjects) of all uncontrolled factors." (WITTE & WITTE, 1997) All of these definitions revolve around the notion of error (i.e., variation) as "random" *because it stems from unknown causes*. However, "randomness" is itself a concept which has acquired a conglomeration of meanings over the course of its history—some of which are taken over into the concept of random error, and some of which are contradicted. [19]

4. What is Randomness?

The idea of randomness has had many definitions throughout its history. LAPLACE (1814) thought of the idea of randomness as an indication of human ignorance of the initial conditions which give rise to the observed outcomes. CICERO (44 BC/1928) thought of a random happening as one that might not have occurred at all or might have occurred in any other way. HUME (1739) built a subjective definition of randomness based on the same notion of equal probability. He thought that equally probable outcomes produce a mental state of indifference in the observer, who has no reason to prefer or expect one over the other. Of course, this has as much to do with "objective" equality of probability as the "subjective" assumption, guess, or feeling of it. The question of how anyone really knows the probability of anything happening is raised, but not answered. There were also frequentistic approaches to randomness, based on the idea that (infinite, long-run) previous experience of some phenomenon should show us that various outcomes are equally probable, leaving the outcome unpredictable at any particular instant. Thinkers such as John Stuart MILL (1843) followed this line. [20]

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In the 20th Century, mathematical definitions of randomness began to appear. With it came a shift toward judging specific observed outcomes as occurring in random (unpredictable) order or not. Perhaps the earliest was offered by Richard VON MISES (1939), who defined randomness in a sequence of observations in terms of the difficulty with which one could predict the appearance of a certain result in the sequence without prior knowledge of the sequence. VON MISES (1939, p.20) named a sequence for which no formula or rule could name particular members of the sequence a "Kollektiv". [21]

In contrast, nonrandom sequences are often describable in terms of position of particular outcomes in the sequence, what he called a "rule of place selection". For example, the sequence 123487640964 would be describable by the rule "every fourth digit is "4". The strongest critique of VON MISES' concept of randomness revolved around his condition that all possible rules must be rejected in order for the sequence to be random. However, in 1963, Andrei KOLMOGOROV published a paper demonstrating that if only "simple" formulas were allowed, then sequences of the kind envisioned by VON MISES would exist. KOLMOGOROV himself worked toward the idea that degrees of randomness could be judged by the complexity of the formula (judged by length and the amount of information contained in the formula) necessary to generate the sequence. For him, an ultimately random sequence could only be described by itself. Not surprisingly, KOLMOGOROV's attempt to define randomness run into the same kinds of problems as VON MISES'. That is, while an infinite (i.e., "long-run") sample may be able to exhibit the kind of randomness that VON MISES was discussing, any shorter "random sample" from that sequence should be able to be fit to some formula or rule. [22]

Does it change the basic quality of the sequence if we know the rule beforehand or only after? In other words, if we are in the middle of a "game of chance" and discover some rule that happens to apply to the sequence of outcomes up to that point (N), and allows us to bet successfully for the rest of the night (N+1 –> N+K), has the "game of chance" become a game of "non-chance"? Do we have to wait until N+K+1 to find out? Or should we wait until a run of "bad luck" returns our winning percentage to the *a priori* level? And then what? A VON MISES-type definition of randomness implies the notion of randomness as a limit, or the idea that as disorder/randomness of a sequence approaches 100%, the number of formulas or rules capable of describing that sequence approaches 1. [23]

A basic question still remains: is randomness a property of the observations or of the process producing those observables? Or both? VENN, father of the famous diagrams, and supporter of the "long-run" frequentistic notion of probability used within psychology today, said in his *Logic of chance* that randomness refers to the "nature of a certain ultimate arrangement[, not] the particular way in which it is brought about" (VENN, 1866, p.108). VENN goes on to say that if the arrangement is too small, then examination must turn to the process producing the arrangement. Others claim that randomness is not a property of any sample or of the process producing the observations in that sample, but rather a property of the procedure of sampling. For example, a table of random numbers, if made

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large enough, should, at some point, include a long (seemingly non-random) run of zeros, to use Ian HACKING's (1965) example. This same paradox is illustrated by G. Spencer BROWN. [24]

A truly random process would be one that is not guided in any way or subject to any law. This is what BROWN (1957) calls "primary randomness". This leads to the idea of "external" randomness as the absence of discernable pattern among the outcomes (i.e., "secondary randomness"), which leads us to the paradox of their relation, which ACREE (1978) explains nicely. Random processes are just as likely to produce orderly-looking sequences as disorderly-looking ones. If there is, for example, a string of 100 coin flips that come up heads, and our sample size happens to be 100, we would not even bother performing the statistical test before rejecting the hypothesis that the coin is fair. However, a primarily random process is just as capable of producing such a string as it is of producing any other string. On the other hand, if we flipped 100 times and the results were exactly 50/50, but the sequence of flips was head-tail-head-tail ..., we would suspect the coin of "non-fairness". On a third hand, if a too many successive series of 100 flips came out exactly 50/50, regardless of the sequence of heads and tails, we would suspect the coin even though the results obey the law of chance perfectly. We only feel comfortable calling a sequence of results random if it has an intermediate amount of unpredictability (ACREE, 1978). Thus, randomness can only be a true characteristic of the hypothetical hyper-long run (which is impossible to ever see). Any sample may or may not be random in itself (according to "secondary randomness"). The concept of random error operates under the definition of secondary randomness (unpredictability), since the law of errors is not compatible with the idea of primary randomness. If random error was truly primarily random (according to this definition), large disturbances would be as likely as small ones, which would be antithetical to the law of errors (i.e., random error would no longer be normally distributed). Primary randomness of the error term would eliminate the utility of any statistical test that relies on the concept. [25]

These perspectives on randomness circle around a single idea: the unpredictability of future events based on past events. Theoretically, this anti-inductive idea fits well with the notion of development, where the focus is on how the future becomes different than the past. However, the inductive model is the one used by methods of statistical inference and assumes that the futures of the past (i.e., the previously accumulated data) are the same as—or at least bear some privileged form of resemblance to—the futures of the present (i.e., what still might become). Thus, history is not doomed to repeat itself eventually. It *has to* repeat itself *constantly*. It really can do nothing else. In the clockwork universe of the determinist, there is nothing but what always has been and always will be. This is not true in the case of a developmental perspective, which entails the emergence of novelty in the moment-to-moment processes of transformation and maintenance of a system. [26]

5. What is Development?

The emergence of novelty—be it age-based growth or the emergence of new psychological functions—is taken by some (e.g., VALSINER, 1997a, p.190) to be the hallmark of development. This presents problems for deterministic frameworks, which may not be able to handle instances where the child, instead of performing X under conditions A,B,C, as usual in the past, begins to do K, and then comes to do K consistently—even more often than X. The pattern of novel forms appearing and then gradually becoming more prevalent than older forms is so common within cognitive development that it has prompted SIEGLER to make the general claim that cognitive development is "better thought of in terms of changing distributions of ways of thinking than in terms of sudden shifts from one way of thinking to another" (1997, p.2). The focus on distributions calls for the centrality of variability within studies of development. This is not the same as GALTON's notion of the statistical unit, which mainly focused on the inclusion of a certain range of inter-individual differences as a more adequate basis for representing the state of humans in general. The focus implied by SIEGLER's work is on *intra-individual* variability. Thus, if the sequence A-X-C has been noticed in the past (A-X-C-A-X-C), the appearance of Y (i.e., A-X-Y-A-X-C-A-X-Y) can either be considered as "error," when compared to A-X-C, or as the seeds of developmental transformation. The latter option is only available if time is included on the level of the individual case, as opposed to the time-free aggregation of previous sequences. [27]

Obviously, from this perspective, inductive lines of inference and prediction based upon frequency distributions of past events cannot serve psychologists well in understanding (or predicting) development. In the "frozen world" of the determinist (to borrow VAN GEERT's 1997 phrase), things are as they are forever and ever and this stability is given by an inherent, transcendent nature. Therefore, aggregation and prototyping of data is the best way to transform our constant observation of the world into an imperfect representation of the eternal essence of the universe. "Error" becomes definable relative to those ideal forms. That is, variations within the presumably stable phenomena are accidents and are expressed in terms of the theory of chance errors. However, in the case of development as shifting forms of variability, "error" becomes indefinable because the previously accumulated data (i.e., the past, which serves as the basis for inductive inference of what reality must be like) can no longer be said to represent the "true state" of the psychological system, which is constantly innovating itself. Indeed, it is just as easy to characterize novelty as "error" relative to the past as it is to declare the past "error" relative to the new present. [28]

As DODGE (1924) points out, variability must be accepted as real without apology and incorporated into any model of human phenomena. Even the most reliable techniques, instruments, and records will not eliminate variability (DODGE, 1924). In addition, intra-individual variability cannot be reduced to error, as is possible in non-developmental sciences studying relatively static objects such as descriptive astronomy. But why? Joachim WOHLWILL put the question succinctly when he asked, "That averaging results in a loss of information is hardly more than a truism; the question is whether the information lost represents true information, or merely noise." (WOHLWILL, 1973, p.140) In order to give some answer to that question, we can look into the different ways in which developmental and non-developmental takes on science conceive of stability. This is important because stability is the conceptual background against which variability is highlighted and characterized. The ways in which that background is set up will lead to correspondingly different ideas about the nature of intra-individual variability. [29]

6. Axiomatics of the Developmental/Non-developmental Distinction

The non-developmental perspective is based on the axiom of identity (VALSINER, 1997b):

X = [is] = X

This axiom holds strong implications for how variability is handled because it portrays a world of static stability, to the exclusion of any variability. Change is excluded since variability plays no role in traditional identity. If X is ever anything but X, it is no longer X at all. Under the axiom of identity, therefore, variation, particularly intra-individual variation, cannot be taken as true variability of the phenomenon under study (X). Rather, such variability is packaged as error variance and disposed of. Within this frame, variability and change require exceptional explanations (cf. SIEGLER, 1994, 1997) because stability is assumed as the natural state of the psychological system. [30]

In contrast, the developmental perspective is based on the axiom of becoming, which takes two forms (VALSINER, 1997b):

X –[becomes]–> Y

X –[remains]–> X

The dual nature of the axiom of becoming indicates the presence of both change and stability within development. Variability plays a central role in this axiom. While this may be obvious in the case of "becoming," it is also true in the case of "remaining." There, the particular system maintains its general form only by constantly replacing old parts with new ones. Stability on one level depends upon constant variability at another. For example, cells within the brain are constantly dying and being replaced, while the brain, as a whole, is maintained. In this way, X –[remains]–> X is not the same as X = [is] = X. In the case of remaining, the process of maintaining innovation is implied, while the axiom of identity is blind to the basic processes that make identity possible (VALSINER, 1997b). In other words, the dynamic side of stability is neglected in favor of classification of the relatively stable products. However, once that classification takes place, the basic difference between conceptualizing the psychological system in terms of a dynamic versus static stability (i.e., as concrete and living vs. non-living, otherworldly, or transcendental, respectively) is lost, leading to potential

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inconsistencies between theoretical and data-analytic features of the research situation. [31]

6.1 Finding a place for intra-individual variability

The case of X –[becomes]–> Y is not taken to say that Y replaces X within the psychological system in the way that new chips replace old ones inside computers. Instead, the human mind is thought of as a system which is constantly elaborating itself. In that elaboration, the functions present at one time (e.g., X) are not lost, but function as part or subsystem of the new Y (which, for example, may be now capable of utilizing different kinds of means) while the integrity of the whole is maintained. [32]

The axiom of becoming implies variability as the background from which stability (i.e., patterns of activity) may emerge, disappear, or become elaborated. In contrast, the axiom of identity implies a static quality or system setting that characterizes the true nature of any given psychological process. The basic idea (following from the axiom of identity) is that psychological phenomena are inherently static forms and invariant across contexts. This invariance is only possible because the forms which the psychological processes take seem to be separate from the processes themselves—different disembodied templates which somehow shift and re-shape the underlying processes upon their application. These static forms or templates are themselves unaffected by the context or situation (FISCHER & BIDELL, 1997, p.476), leading to variability in performance being explained away, rather than understood. [33]

The importance of variability becomes apparent once psychological phenomena are placed within their context (which the theory of static, otherworldly forms and causal essences has no particular reason to do). Once there, variable environmental conditions affect different systems differently and affect a single system differently across time. John NESSELROADE is very clear about the idea that the effects of contextual factors are mediated by the power of living systems to self-stabilize and self-organize (i.e., the abilities to maintain a way of functioning in the face of perturbations or to find a new mode in the face of demands that exceed the system's capacity for self-stabilization):

> "What is being subjected to internal and external influences that help to shape the organism is not a lump of clay, but, rather, a vibrant, somewhat labile [flexible in WERNER's terms—S.S.] organism that is already pulsating to a multitude of rhythms." (NESSELROADE, 1991, p.231) [34]

Given the self-stabilizing capacity of living systems, this intra-individual variability can be thought of as coherent, meaningful, and *functional*, rather than as noise. In other words, variability serves two purposes. It is central to self-regulation (i.e., "remaining" or maintenance) of living systems and the source potential mobility. That is, intra-individual variability provides the "loose strings" to be woven or "whispers" that may be amplified (a la the notion of "persistent imitation"—

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BALDWIN, 1894). It is the "basic stuff of development" (NESSELROADE, 1991, p.214). [35]

7. Development and "Fuzzy Phenomena"

Following from this, developmental phenomena can be seen as those which include time-bound, irreversible transformation of structure and/or function of an organized system through processes of organism **<–>** environment exchange. Thus, the developing system is constantly going beyond what has already been accomplished and moving toward what is about to be mastered. This violates the deterministic ideal of immutable products of immutable laws. Developmental phenomena, in DEWEY's words, "manifest deficiency of sure foot in in Being by the very fact of change. [They are] infected with *non*-being." (DEWEY, 1929, p.18). He continues:

> "If a thing changes, its alteration is convincing evidence of its lack of true or complete Being. What is, in the full and pregnant sense of the word, is always, eternally. It is self-contradictory for that which is to alter. ... That which becomes merely *comes* to be, never truly is. It is infected with non-being ... The world of generation is the world of decay and destruction. Wherever one thing comes into being something else passes out of being. ... The idea is so familiar that we overlook the unexpressed premise ... that only the completely fixed and unchanging is real." (DEWEY, 1929, pp.19-21). [36]

From a developmental perspective, systems of all kinds—psychological, societal, biological, etc., are constantly transforming themselves. This perpetual state of transition is the element of "non-being" that must accompany every moment of stability in the system and which allows for its transformation (cf. JOSEPHS, VALSINER & SURGAN, 1999 for an example of this within the process of meaning-making). That is, most phenomena combine features that are in the process of disappearing with those that are in the process of coming into existence (VALSINER, 2000). [37]

Within such processes, the move from one structure-function to another entails the transformation of one into the other. This kind of inherent, systemic growth is unpredictable beforehand, although an average may be describable and used as a means of prediction. Ludwig von BERTALANFFY called for the systemic analysis of development as an alternative to the use of the average as a means of prediction and golden standard against which outcomes could be judged:

> "Experience shows us that the 'whole' upon which determination [i.e., development—S.S.] depends *is not the typical result in the future, but the actual state of the developing system at a given time which can be indicated in any particular case*. To be sure, inasmuch as determination has not yet taken place, there is equifinality, that is, the same end-result can be reached from different initial conditions. However, development does not proceed 'purposively' in the sense that the best and most typical result is achieved, as should be the case with an entelechy directing events in foresight of a goal. What really happens, whether, when, and how regulation occurs,

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> is unequivocally determined by the conditions present." (BERTALANFFY, 1960, p.59; emphasis added) [38]

However, as James Mark BALDWIN makes clear, those conditions are just that—conditions—and not causes in the deterministic sense. For him, this issue of modes of inference was at the center of the conceptual divide between developmental (genetic) and non-developmental (agenetic) sciences:

> "We must be free from all constructions from the strictly agenetic sciences in which the causal sequence is the typical one. The birth of a new mode in the psychic life is a 'progression' form an earlier set of conditions, not the effect of those conditions viewed as a cause; and this is equally true of any new genetic mode, just so far as the series in which it appears is really genetic at all." (BALDWIN, 1906, p.29) [39]

BALDWIN's objections stem from the idea that transformation of developmental (genetic) phenomena into "statistics fuel" eliminates crucial aspects of those phenomena. In particular, techniques of aggregation, disintegrate the systemic (holistic) and temporal (time-inclusive) organization inherent in developing systems. [40]

8. Random Error and the Concept of Development

The basic contrast that emerges from this discussion of the concepts of random error and development centers on the study of variability. The statistical study of variability is historically rooted in the theory of errors and the study of stable, fixed quantities such as the position of celestial bodies. This idea of error assumes the inherent stability of its referent. As such, variability should not—and cannot, according to the notion of error and the ontological claims implicit within it—stem from the object to be measured. In contrast, the concept of development assumes the inherent growth and change of the "genetic totality" (WERNER, 1957). From this angle, intra-individual variability serves two purposes. It is potential mobility for the system in transforming itself and also part of the mechanism of maintenance under variable conditions. Variability, order, stability, and change are all related in the case of a dynamic, living system. If we assume inherent growth and change—or at least grant the possibility of it—and acknowledge that these time-dependent processes are part and parcel of developmental transformation, the average loses its status and "error" becomes difficult to define. [41]

Secondly, because error is defined as deviation from the true value, which is given by the mean, error is an aggregate-based concept. However, it is not the aggregate that develops. Only organisms (broadly conceived—individuals, societies, ecosystems) develop. As such, the reference to an aggregate seems to be an unnecessary extra step if the goal of the particular study is to understand how development takes place within a given organism or psychological system. This is true even at the minimum case of two consecutive events: A(t) –> B(t+1). The pair gives either "error" (B as deviation from A—or vice-versa), when the pair is aggregated, or possible development (A –> B), when considered as linked by some time-inclusive, transformative process. Aggregation of data entails ignoring the holistic nature of the phenomena from which those data were derived. For example, the procedure of isolating outcomes from the life processes of the organism in which the phenomena find their natural "home"—and aggregating those outcomes—ignores potential qualitative differences in the process of the genesis underlying different outcomes in different individuals. [42]

The focus on understanding processes of development stems from the status of developmental psychology as an historical science. That is, at the heart of developmental methodology is the "axiom of historicity" (VALSINER, 2000, p.58). That axiom claims that "the study of the time course of the formation of selected phenomena can explain the present state of these phenomena". Proponents of inductively-driven determinism may claim adherence to the axiom of historicity. For example, if the sequence 1-4-7-10 was observed, the algorithm N(t+1) = N(t) +3 may be derived, allowing predictions of the future states of N to be made (i.e., 13-16-...). However, this approach could not be characterized as developmental because it implicitly subscribes to the axiom of identity. The axiom of identity gives birth to two models of development. The first is a replacement model, where static forms (e.g., stages) are invariant across contexts and undergo a mysterious process of transformation, within which variability appears from nowhere as the marker of transition—e.g., disequilibration. After the burst of variability, a qualitatively different static point (stage) is reached. In this case, development proceeds in a linear fashion, up the developmental ladder of stages. The second model allowed under the axiom of identity is the "continuity" model (BIBACE, DILLON & SAGARIN, 1998). In this model, development is equated with maturation and proceeds as a more-or-less continual, inexorable sequence, as in the "N+3" example. This is a slight twist on the axiom of identity, but it nevertheless fits. Since the generative algorithm which gives rise to the particular steps of the unfolding is pre-programmed and therefore an inherent part of X, the entire course of development can be characterized by the expression X = [is] = X. [43]

The axiom of historicity implies that data records must include time as a dimension along which the phenomena are mapped. This is impossible in the case of aggregation. In addition, rich empirical description of individual cases must not only include time, but as much variability as can possibly be observed in the phenomenon. Left alone for "naturalistic observation," the system in question may display neat sequences such as 1-3-7-10-13-16. However, that may not capture the full range of *possible* variability. Manipulation of conditions within the research setting may elicit a greater range of responses from the individual. This idea has been formalized in VYGOTSKY's "zone of proximal development" and SIGEL's (1993) psychological distancing activities. Empirically, this is clear in the work of BIBACE and his colleagues (BIBACE, SAGARIN, DYL, 1998), where an upper limit (in terms of developmental levels) is found in children's conception of illness (even beyond which psychological distancing activities cannot take them), but no lower limit is found for adults. That is, adults, having reached "16" are capable of demonstrating "7," even though "16" has indeed appeared. If the nature of development was adequately captured by continuity or replacement models, such variability would not only go unseen—it would be *a priori* impossible. However, earlier forms of functioning are not simply lost when novel forms appear. They are subordinated within the newly complexified system and may appear under specific conditions. For WERNER, this kind of ability to be variable was extremely important for the continuing survival of any living system and to be expected from any individual. He wrote, "... a child of a certain age or an adult, depending on the task or on inner circumstances, may, qua normal, perform at genetically different levels (WERNER, 1957, p.138). [44]

WERNER's "co-existence" model has been carried over (though without references) as one basis of contemporary dynamic structural thought under the name of "developmental range" and is illustrated in studies by Kurt FISCHER and his colleagues (LAMBORN & FISCHER, 1988; FISCHER & BIDELL, 1997), who demonstrate the conditional mobility of the person between genetic levels in their study of functional and optimal levels (FISCHER & PIPP, 1984; FISCHER et al., 1997; FISCHER & KENNEDY, 1997). FISCHER and BIDELL (1997) write:

> "A fundamental error stemming from static conceptions of psychological structure is that each individual is treated as "possessing" one fixed level of structure. ... From this point of view, an individual's behavior is expected to be homogeneously consistent with the fixed level of cognition" (FISCHER & BIDELL, 1997, p.483). [45]

Demonstrating the full range of possible variability within the phenomenon of interest (and accepting that variability as telling us something important about the history and nature of the phenomenon) is central to any developmental perspective because the developmental scientist is also after general knowledge —in terms of general models of time-inclusive processes. Variability—both within cases and between them is necessary for the testing of those models. The issue at stake is a general one: How can knowledge be created on the basis of dynamic phenomena? We cannot automatically rely on quantitative or qualitative methods for easy salvation. The adequacy of and set of methods or data analysis procedures depends upon satisfactory linkages being explicitly drawn between the various components of the methodology cycle (described above). Thus, development cannot be studied through conceptual tools that are not capable of handling changing phenomena. Error is a concept that assumes the stability of an outcome or measurement. Development, on the other hand, is a dynamic process leading to the emergence of novelty. [46]

In the beginning of this paper, I put forward the notion of data as inherently perspectival (i.e., assumption-laden) representations of phenomena. This implies that anything can be represented in potentially infinite ways. Variability can be taken as error or as true variability of the phenomena of interest. Different metatheoretical stances lead to different descriptions. Consistency is the crucial benchmark. One possible way to build general knowledge given the axiomatic bases of developmental takes on science is through the construction of general theoretical models which, depending upon the history described, can capture the variety (and likelihood) of the immediate next possible transformations in the phenomena. This sort of effort would capture the variability inherent in any developing system, include some theoretical relation between the real conditions

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under which the system is functioning (beyond causal arrows), reflect the nonlinearity of development (i.e., the multipotentiality of any living system), and eliminate the need for universal, constant causes without sacrificing the generality of knowledge which is so important to any science. [47]

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