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Reply To Commentary:

CATALYSIS:
Cultural Constructions and the Conditions for Change

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Abstract

In the inaugural issue of *JISS*, Puopolo (2009) suggested that a careful examination of affective catalysts in the model of abductive reasoning is needed. Along these lines, I here address: (1) the process of *catalysis* and (2) the concept of *a catalyst*. These will be addressed by concentrating particularly on enzymatic catalysis and autocatalysis. Moving from the life sciences to the social sciences, I then adapt and develop the process of catalysis and the concept of a catalyst in psychology. A psychological catalyst—or a semiotic catalyzer—is conceptualized as a particular meaning—a point-like sign, a field-like sign, or a hypergeneralized sign—within the psychological system that provides the conditions necessary to enable the production and regulation of other meanings in the stream of consciousness of the person. The goal of this paper is to adapt and develop the theoretical process of catalysis and the concept of a catalyst in the psychological sciences and chart out its empirical relevance.

Keywords: Autocatalysis**,** Catalysis, Catalyst, Enzymatic Catalysis, Semiotic Catalyzer

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> My own experience of bereavement and ritual fits the platitudes and catalyst model better than that of microcosmic deep culture. Even a careful analysis of the language and symbolic action during the two funerals for which I was a chief mourner would reveal precious little about the experience of bereavement. This statement, of course, should not leave anyone to derive a universal from somebody else's personal knowledge. Instead, it should encourage ethnographers to ask whether a ritual's wisdom is deep or conventional, and whether its process is immediately transformative or but a single step in a lengthy series of ritual and everyday events.
>
> (Rosaldo, 1989, p. 15)

The process of catalysis can provide for an innovative understanding of phenomena that can further the development of specific psychological models—such as models of abductive reasoning (Cabell, 2009) and models of bereavement (see quote above by Rosaldo, 1989)—as well as psychology as a whole. The concept of catalysis has greatly progressed in the life sciences, most noticeably in chemistry. The abstract function of catalysis in chemistry is to provide the conditions necessary—via a catalyst—but not by itself sufficient to aid in twofold: (1) the production of chemical substances that might not have been produced without the presence of the catalyst, and (2) the change in the rate of reaction that might not occur without the presence of the catalyst. The process of catalysis in chemistry can therefore be abstractly defined as providing the chemical system the conditions necessary—via a catalyst—but not by itself sufficient to aid in chemical production of substances and chemical change in the rate of reaction.

It would be productive to develop the process of catalysis in psychology—at least in a cultural psychology that focuses on the semiotic mediation of psychological functions. By taking the abstract qualities of catalysis in chemistry, we can adapt a catalytic model in the psychological and semiotic system of the mind. In this re-conceptualized process, catalysis would provide the conditions necessary—via a catalytic agent—in order to: (1) *enable the production of novel meanings* through the activation of other mediating mechanisms within the system (for example, mechanisms such as semiotic synthesizers and semiotic initiators) and (2) *enable the regulation of meanings* by activating the other mediating mechanisms within the system (for example, mechanisms such as semiotic promoters and semiotic inhibiters).

In these two brief elaborations of catalysis in chemistry and in psychology, the main function of catalysis remains the same in both disciplines—providing the conditions necessary, but not by themselves sufficient, by inserting a catalyst (or a catalytic agent) in to the system. The catalyst has the same abstract function in both disciplines—functioning as a "helper" in the reaction process. The way in which the catalyst helps in the reaction process is by activation. In psychology, the catalyst or the catalytic agent activates other mediating functions required for the reaction process. In chemistry the help comes from providing resources (energy) that activate the reaction. Although the outcomes of the catalytic process in both disciplines are similar, they slightly differ. In psychology, catalysis enables production of novel meanings and enables the regulation of other meanings. In chemistry, catalysis aids in producing novel chemical substances and aids in changing the rate of reaction. Chemistry retains a half quantitative conceptualization of catalysis (i.e., the rate of reaction) that psychology does not. In this paper, the theoretical importance and empirical relevance of catalysis will be explored as well as the parallels between chemistry's catalysis and psychology's re-conceptualization of catalysis.

Conceptualizing Catalysis in Chemistry:

Much progress has been made in the development of catalytic theory and research. In chemistry, the abstract quality of catalysis is to provide the conditions necessary—via a catalyst—but not by itself sufficient—but not the cause itself—to aid in: (1) the production of chemical substances that might not have been produced without the presence of the catalyst, and (2) the change in the rate of reaction that might not occur without the presence of a catalyst.

The abstract quality of catalysis that provides the "conditions necessary" for a reaction to occur can be illustrated with the process of achieving one of its outcomes—namely, a change in the rate of reaction. When there is an increased rate of reaction, the presence of the catalyst provides the conditions necessary to increase in the rate of reaction by providing unique bonding between the catalyst and other molecule that releases energy. This "lowers" the (original) amount of energy required for the reaction to take place. The decrease in the activation energy required allows for more products to be formed in a shorter amount of time.

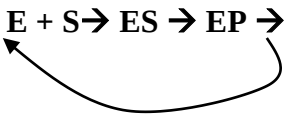
When there is a decrease in the rate of reaction, the presence of the catalyst provides the conditions necessary to "lower" the activation energy as in the last example. However, the presence of poisons or other substances engage in catalytic modification where the intermediate reactions are destroyed or altered. This targeting of the intermediate reactions provide conditions that prevent the bonding and energy release and ultimately prevent the "lowering" of activation energy. Consequently, the catalytic reaction maintains or increases the amount of time the product takes to form—if it can

form at all. Consequently, in chemistry, catalysis is about providing the necessary energy conditions. How these conditions come about requires explanation of a particular type of catalysis, enzymatic catalysis.

Enzymatic Catalysis and Energy Conditions:

One specific type of catalysis is called, enzymatic catalysis, often studied in the intersection of biology and chemistry. Catalytic reactions in enzymatic catalysis require an enzyme—which acts as the catalyst—and a substrate—the molecule being acted upon by the catalyst/enzyme. In most cases the substrate, while interacting with the catalyst, will undergo a transformation and produce a novel chemical agent (or novel chemical agents) at an increased rate of reaction. The interaction of the enzyme and substrate results in the original catalyst/enzyme—not used up in the reaction—and a product (See Figure 1). The general equation used to represent this is as follows:

Figure 1. The process of enzymatic catalysis



In this equation, "E" represents the enzyme; "S" represents the substrate; "P" represents the product; "ES" and "EP" represent intermediate complexes or reaction intermediates.

All reactions require some sort of activation energy—the amount of energy required to form the product. Activation energy acts as an energy barrier—a barrier that prevents reactions from spontaneously occurring (forwards and/or backwards). It is the catalysts function to provide the conditions necessary to reduce the energy barrier—and therefore the activation energy—required for products to form. Although this is a typical case, catalytic processes have also been known not to lower but rather to increase the activation energy and the energy barrier so that products may take a long time to form, or not form at all. But this is the result of a change in the catalytic conditions provided by chemical poisons.

If catalysis provides the conditions necessary by providing the catalyst, what does the catalyst do to create such necessary or sufficient conditions? When the enzyme and the substrate interact there begins to develop small bonds between them. As the bonds form, they release quantities of energy called, binding energy. Similar to a chain reaction, the energy released is used towards forming another bond, and so on and so forth until the bonds forming between the catalyst and the substrate in the reaction intermediates twist and turn the substrate, eventually transforming it into a qualitatively different

molecule. The more bonds formed, the more energy released, the less (extra) energy required to "activate" the formation of the product. The catalyst provides the conditions necessary to release free energy and thusly to decrease the amount of extra energy required to form the product.

Autocatalysis: From Life Sciences To Social Sciences

Another specific type of catalysis is autocatalysis. Autocatalysis is a catalytic process between at least three parts—two catalysts and another molecule—that react in a way that is mutually generating. More descriptively, Deacon and Sherman (2008) describe autocatalysis as:

> To take an oversimplified example, imagine a catalyst, A, that catalyzes certain molecules, bonding them together in such a way that they become a second catalyst, B. Imagine, then, that catalyst B catalyzes certain molecules, bonding them together in such a way that they become catalyst A. (p. 67)

The fascination with autocatalysis rests within its theoretical ability to create organic living systems out of inorganic non-living systems. Hypothetically, all that would be needed is, at the very least, three molecules that react in a way to mutually generate each other (See Figure 2). Due to this property, autocatalysis has been proposed to solve the problem of abiogenesis—how life could have arisen from non-living matter and within non-living systems. It has also been used to link Bateson's *pleroma* and *creatura* (Deacon & Sherman, 2008). Such a move from catalysis to creation is important for my purposes in this paper. Understanding the creation and production of novel forms and novel phenomena is of great importance in disciplines outside of biology, chemistry, and the life sciences—especially in psychology. The importance of creating and constructing psychological products in psychological reactions of semiotic structures requires more theoretical and empirical work in psychology. The catalyst, and autocatalytic processes are important for this work.

Figure 2. The process of autocatalysis

$$C_1 + A \rightarrow C_2 \qquad \textbf{and} \qquad C_2 + A \rightarrow C_1$$

In this equation, "C_1" represents the first catalyst; "C_2" represents the second catalyst; "A" represents the third molecule in the autocatalytic system; Both "C_1" and "C_2" are products and reactants since their interaction with molecule "A" is mutually generating.

Crossing disciplinary borders into cultural and literary studies, autocatalysis has implications in theorizing about the creation and the production of culture(s) and cultural products. Lotman (2000) expresses the use of autocatalysis in the realm of semiotics and culture. He writes,

> The idea that 'thinking' semiotic structures need an initial impulse from another thinking structure and that text-generating mechanisms need a text from outside to set them going reminds us on the one hand of so called autocatalytic reactions, that is those reactions where, in order to obtain the final product (or to hasten a chemical process), the final result has to be already present in some quantity at the beginning of the reaction. And on the other hand, this question finds a parallel in the as yet unsolved problem of the 'beginning' of culture and the 'beginning' of life. (p. 3)

Lotman's use of catalysis—specifically autocatalysis—is used in the psychological realm (of thinking) and therefore autocatalytic processes are theoretically extended in to psychology, semiotics, and cultural studies. But what is most important about Lotman's quote is the statement that no "thinking" or "semiotic" structure can exist alone. Instead, there must be at least one other semiotic structure as an "initial impulse"—an initiating mechanism—or other generating mechanisms. This illuminates that both autocatalysis and cultural semiosis cannot be studied using independent variables but rather understanding is necessarily dependent on the functional relationship between parts—whether the function of the relationship is initiating, text-generating, or something else—as well as the parts in and of themselves.

This emphasis on the relationships between parts in both biochemical autocatalysis and cultural semiosis suggest that both processes must necessarily take place within a system, even if that system only contains two semiotic structures (in cultural semiosis) or three molecules (in autocatalysis). Not only are the relationships between parts within the system important, but also the relationship of the parts to the system as a whole. The functional relationship between "initiating" or "text-generating" structures provides the system as a whole with the quality of mutual generation.

I also would like to draw the parallel between autocatalytic theories and semiotic theories. Just like some theories dictate a minimum of three molecules in an autocatalytic system, Peircian semiotics requires three semiotic structures (a triad model): the sign or representamen, the object, and the interpretant. Both in autocatalysis and in semiotics the role of the parts and their relation to one each other in the overall system are key. For autocatalysis, the parts must include at least two catalysts and another molecule. The process in autocatalysis must require mutually generating pathways—the parts relation to one each other by producing one another. Quite similarly, meanings—whether

"produced" or "consumed"—emerge in sets of three signs. In relation to one each other, they form a meaningful system in which, for example, an object is encoded into a representamen, and then decoded by its interpretant. Autocatalysis brings forth the importance of both the parts and their relationship to one another as well as the system over all.

Semiotic Catalyzers: Enabling Production and Regulation

In the previous section, a parallel was drawn between theoretical understanding of autocatalysis in the life sciences, to the semiotic and psychological understanding in the social sciences. I wish to continue with this parallel, adapting the abstract qualities of catalysis to psychological phenomena, and developing them further theoretically and empirically.

It has already been stated that the abstract function of catalysis in chemistry is to provide the conditions necessary—via a catalyst—but not by itself sufficient—but not the cause itself—to aid in: (1) the production of chemical substances that might not have been produced without the presence of the catalyst, and (2) the change in the rate of reaction that might not occur without the presence of a catalyst.

Adapting these abstract qualities in to psychology, the process of catalysis is defined by its ability to provide the conditions necessary—via a catalytic agent—but not by itself sufficient to: (1) *enable the production of novel meanings* through the activation of other mediating mechanisms within the system (for example, mechanisms such as semiotic synthesizers and semiotic initiators) and (2) *enable the regulation of meanings* by activating the other mediating mechanisms within the system (for example, mechanisms such as semiotic promoters and semiotic inhibiters).

Catalytic Causality: A—{*helps*}→ B; A—{*activates*}→ B

In both of these models, catalysis is a process of providing the conditions necessary by providing a catalyst. In both cases, these conditions are necessary, but not by themselves sufficient. In both cases, the catalyst does not *cause* in the strict sense of *A--{causes}-->B*, or "if preceding cause, then following effect". For example, in some cases, and across both disciplines, the product can still form without the conditions presented by the catalyst. Although this may require a long period of time or other necessary conditions, it is still possible. Therefore the catalyst is not a causal concept.

If not causal then what? The catalyst has the same abstract function in both disciplines—functioning as a helper in the reaction process. The way in which the catalyst helps in the reaction process is by activation. In psychology, the catalyst or the catalytic agent's activate other mediating functions required for the reaction process. In chemistry the help comes from providing resources (energy) to activate the reaction. This

calls for a re-conceptualization in causality as understood in psychology. What kind of inference models can be created using a semiotic catalyzer that engages in supportive mediation, and not a direct causal effect?

The question of catalytic causality also brings to light the question of evaluating causality—quantitatively versus qualitatively. In chemistry, there is a definite quantitative measure of the increase (or decrease) in the rate of the reaction. However, if catalysis is to be adapted in to psychology and such quantitative measures are not useful for its theoretical purposes. Instead, qualifying the developments—emergence, maintenance, or disappearance—of meanings and other mediating mechanisms is what is central to the object of inquiry. These qualities can be seen in empirical examples.

Charting Out Catalysis Empirically: Systemic Oddity and Catalytic Normality

Semiotic catalyzers can provide the conditions necessary to enable the production of novel phenomenon by activating one or more mediating mechanisms within the cultural-psychological system. The various mechanisms and their functions have yet to be completely studied. However, such an inquiry is essential, as certain mechanisms are required for producing, re-producing, synthesizing, decomposing etc meanings and their phenomena in the cultural-psychological system. A catalysts interacting with a semiotic-synthesizer would activate synthesizing functions and enabling the production of unique phenomena to occur that would not normally. For example, guns, students, and schools co-exist every day. However, the co-existence of these three parts does not consistently result in school shootings every day. There must be some catalytic processes that enable the synthesis of, at the very least, all three parts into the novel behavior in the case of school shootings (See a more elaborate example of systemic causality and violence in Valsiner, 2007, p. 377).

Catalyzing Meanings in a Time of War: From Friend to Foe

The same goes for the conditions of war—a systemic oddity that occurs only at specific times and under specific conditions despite the fact that the parts of the system—weapons, governments, and allies/enemies—co-exist for the majority of the time. Leo Tolstoy (1886) describes one particular catalyst—the generalized feeling of war—enabling the production of novel (and unfortunately negative) behaviors of war—killing and mutilating fellow men. Tolstoy (1886) writes,

> During these twenty years fields innumerable remained unploughed and untilled; houses were burned; trade ran into new channels; millions of men became impoverished, millions grew rich,

> emigrated, *and millions of Christian men,--men who professed the law of brotherly love,--killed each other!*
>
> *What does all this mean*? What was the cause of it all? What was it that drove these men to burn the houses and mutilate the bodies of their fellow men? What reason was there for this state of things? *What power could have so influenced men to act in a manner so unusual?* (p. 327, *emphasis added*)

The catalyst in this case is the generalized feeling of war. A declaration of war is made through a formal speech or a formal signing—and sometimes without either. And yet, with the few words that are given in a speech declaring war, or with the few seconds it takes to sign a declaration of war, there can result the transform of beliefs, attitudes, and perception of a whole nation. This transformation occurs drastically and rapidly. The general atmosphere changes, and this change in atmosphere sets the stage for the activation of semiotic mechanisms that might produce novel thoughts, feelings, and behaviors. The general feeling of war—the semiotic catalyzer in this case—enables the activation of promoter mechanisms to preserve one's own life and one's own nation, while inhibiting many empathetic (and sympathetic) feelings or affects that might prevent you from targeting "the enemy". Quite similarly, novel feelings of hatred, disgust, or inexpressibly negative feelings might emerge as the feelings of war synthesizes new perceptions and representations of the men who you are now fighting against. To switch from "brotherly love" to "enemy hatred" necessarily requires the whole psychological system to re-frame itself, becoming a semiotic catalyzer that activates synthetic and regulative mechanisms, resulting in other thoughts, feelings, and behaviors that are context-specific to war and condition-specific to the semiotic catalyzer of generalized feelings of war.

Activating Synthesis: Catalysts Function in Ruptures

The drastic and rapid transformation that is attributed to the engagement in war may be called a "rupture". Zittoun, Duveen, Gillespie, Ivinson, and Psaltis (2003) discuss the link between the transition or ruptures in meaning systems and catalytic processes. Zittoun et al. (2003) write,

> Processes linked to 'transitions' are processes of elaboration related to the construction of meaning following a rupture in the 'taken for granted' or the emergence of something otherwise unexpected. In such circumstances the activity of meaning construction may need some kind of catalyst; it is when people lose the common ground, the taken for granted, that they have to re-create meaning. (p. 417)

When ruptures occur, and meaning systems "bottom-out", some process must be activated in order to start re-building and re-producing the meaning system. It is the semiotic catalyzers function to activate re-producing and synthesizing mechanisms to rebuild the meaning system. The catalyst, then, coordinates the mechanisms in the system to re-frame the mind and re-build its meaningful system. This re-building of meaning in the cultural-psychological system after a rupture is illustrated in Tolstoy's quote above when feelings of "brotherly-love" for a "fellow men" one day is ruptured by war. The "dropping-out" or "bottoming-out" of the meaning system in place begins to be re-framed and re-built according to the new semiotic catalyzer in place—the generalized feelings of war. This re-building enabled the transformation in meaning to sustain the killing and mutilation of fellow men that have become re-labeled as "enemies". However, this mass killing and mutilation would not occur without the transformation of the meaning system enabled and activated by the catalytic effects of generalized feelings of war. When war ceases, what allows for the state of things to return to what it was like before the war—without mass killing and mutilation? The transformation to war and back is truly an oddity—a naturally occurring event what warrants a particular meaning system and particular actions that would occur in no other situation. It is for phenomena like this that semiotic catalyzers are essential theoretical tools for understanding.

Conclusion:

The role of the semiotic catalyzer as a particular meaning—point-like meaning, general field-like meaning, or hypergeneralized meaning—within the psychological system that provides the conditions necessary—but not by itself sufficient—to enable the production and regulation of other meanings within the psychological system provides a fruitful theoretical and empirical contribution to the field of psychology. In psychology, the result of catalysis is twofold: (1) *enable the production of novel meanings* through the activation of other mediating mechanisms within a system and (2) *enable the regulation of meanings* by activating the promoter or inhibiter mechanisms within a system (promoter signs and inhibiter signs). A useful tool for cultural psychology, Lotman (2009) comments on the catalyst in culture. He writes,

> Finally, it may play the role of the catalyst: without participating directly it may, nevertheless, accelerate the dynamics of the process as represented, for example, by the intrusion of Chinese art into the structure of baroque. In this latter case, the intrusion will take the form of a fashion, which appears, interferes in the dynamics of the basic culture, only then to disappear without trace. Such, in essence is the function of fashion: it is intended to act as a metronome and catalyst of cultural development. (p. 134)

A catalyst, situated within the cultural dynamics of meaning in mind and society, has the potential to change the course of a given cultural trajectory—for better or for worse. It is the duty of social scientists alike to learn the intimacies of the catalytic functions in order to understand the oddities that perpetuate themselves within our socio-cultural and historical settings.

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