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## Biographical Sources and Systematic Studies of Aspects of Creative Work in Science

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Any biography of historically influential individuals faces the problem of how to balance the achievements of their work and their private life. It is obvious that some scientific discovery, artistic breakthrough, or philosophical insight can be better appreciated if private affairs, particularly including their psychological manifestations, accompanying the development of such an achievement are considered and understood. Hankins (1979) supports this view:

We can say at least one thing with certainty about biography: the ideas and opinions expressed by our subject came from a single mind and are integrated to the extent that that person was able to integrate them in his own thoughts. ... Science is created by individuals, and however much it may be driven by forces from outside, these forces work through the scientist himself. ... Letters written under great emotional stress are the best grist for the biographer's mill, because they lead straight to the heart of the subject's personality and reveal the groundsprings from which his actions come."

Nevertheless there is a tendency to underrepresent psychological elements in biographical work. According to von Meyenn (1997),

a still neglected chapter in the history of science literature is the integration of psychological factors, which Stefan Zweig has demonstrated in his historical portraits. For a complete description of the forces shaping individuals and, hence, their scientific work, their *psychological conditionality* would have to be included together with *internal scientific constraints* and *social boundary conditions*. Since in most cases access to the necessary source material is restricted by a screened private sphere, such an enterprise can only be carried out under exceptional circumstances.

There are a number of cases in which, at least to some extent, such exceptional circumstances are given. For instance, quite a body of material is available for Helmholtz, Einstein, Poincaré, Pauli, to mention just a few. For more sources the reader may consult classic volumes by Paulhan (1901), Wallas (1927), Hadamard (1954), or – more recently – Kantorovich (1993) or Miller (2000). Another selected collection of highly interesting quotes can be found in Simonton (1988), whose research for three decades has been devoted to a detailed understanding of the psychological processes associated with creative work and insight.

On the basis of a wealth of biographical material on creative thinking, Hadamard (1954) suggests four stages, each of which is inevitable for genuinely creative work.

He calls these stages *preparation, incubation, illumination, and verification*. The first and the last of them mainly function at the level of conscious, analytical thinking. The second and the third stages, however, strongly involve unconscious processes as the core of actual insight. Let me cite two quotations, by Poincaré and Einstein, as examples. In his essay on “Mathematical Creation”, Poincaré (1913) says:

One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. ... It seems, in such cases, that one is present at one's unconscious work, made partially perceptible to the over-excited consciousness, yet without having changed its nature. Then we vaguely comprehend what distinguishes the two mechanisms or, if you wish, the working methods of the two egos.

Most striking at first is this appearance of sudden illumination, a manifest sign of long, unconscious prior work. The role of this unconscious work in mathematical invention appears to me incontestable. ... Sudden inspirations ... never happen except after some days of voluntary effort which has appeared absolutely fruitless and whence nothing good seems to have come, where the way taken seems totally astray. These efforts then have not been as sterile as one thinks. They have set going the unconscious machine and without them it would not have moved and would have produced nothing.

Einstein (ca. 1905) responded to a questionnaire by the French psychologists Claparède, Flournoy, and Fehr, published in *L'Enseignement Mathématique*, with the following words:

The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements of thought are certain signs and more or less clear images which can be ‘voluntarily’ reproduced and combined.

There is, of course, a certain connection between those elements and relevant logical concepts. It is also clear that the desire to arrive finally at logically connected concepts is the emotional basis of this rather vague play with the above mentioned elements. But taken from a psychological viewpoint, this combinatory play seems to be the essential feature in productive thought – before there is any connection with logical construction in words or other kinds of signs which can be communicated to others.

The above mentioned elements are, in my case, of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary stage, when the mentioned associative play is sufficiently established and can be reproduced at will.

These two selected quotations could be supplemented by many others. Here is a compact characterization of Hadamard's stages with some additional comments.

1. *Preparation*: As Poincaré emphasizes, no creative insight can “happen except after some days of voluntary effort which has appeared absolutely fruitless”.

Intense conscious work on a problem, sometimes even for years (as Gauss (1805) reports in a letter to Olbers), precedes the final solution. Frustrating efforts without success characterize this stage.

2. *Incubation*: At some point the problem is removed from conscious focus, intentionally or by distraction, but the preceding conscious work “has set going the unconscious machine”. Unconscious elements “rose in crowds; I felt them collide” (Poincaré), and “this combinatory play seems to be the essential feature in creative thought” (Einstein). According to Simonton’s (1988) model, permutations of unconscious elements form and dissolve involuntarily by chance.
3. *Illumination*: When “the mentioned associative play is sufficiently established” (Einstein), “pairs [of unconscious elements] interlocked, so to speak, making a stable combination” (Poincaré). A particular configuration of unconscious elements stabilizes and, thereby, becomes conscious. This is the crucial moment in which an insight reveals itself. Often this happens holistically, not successively unfolded in time.
4. *Verification*: Finally, this insight has to be reconstructed in a logical way, i.e. by a succession of rational arguments which can be communicated. “Conventional words or signs have to be sought for laboriously only in a secondary stage” (Einstein).

In Simonton’s fairly detailed “chance–configuration model” (Simonton 1988) for the second and third stage, there is one central issue: stability. The permutating unconscious elements during incubation are not (asymptotically) stable, but float freely, coming and going by chance. Only a particular one among these configurations has stability properties implying its transition into a conscious idea. In a Darwinian formulation of creative processes, stability provides a selection criterion among many chance possibilities. For other features and consequences of this model, see Simonton (1988).

The question of why and how particular configurations are distinguished by their stability remains unresolved though. In this respect, some speculative ideas addressed by Pauli and inspired by Jungian depth psychology are of interest. Pauli (1952) proposed the idea of psychophysical correspondences (“synchronicities”) between psychological and physical subdomains of an underlying hypothetical background reality.

The process of understanding nature, as well as the blissful experience in this process, when a new insight becomes conscious, seems to be based on a correspondence, a kind of congruence, of inner images pre-existing in the human psyche with external objects and their behavior.

At this point it seems most satisfactory to me to introduce the postulate of a cosmic order, eluding our direct access, which is distinct from the world of appearances. ... The relation between sensual perceptions and ideas would

then follow from the fact that both the soul of the observer and the observed object are governed by the same objective order.

The origin of the stability properties addressed above could then be conceived at the level of this objective, psychophysically neutral order, and stable configurations would manifest themselves in the selection of particular correspondences out of many possible ones. Examples of serendipity as described by Simonton (1988), resembling features of Jungian synchronicity, are interesting candidates fitting into this picture.

Summarizing, this contribution outlined how biographical material can be useful beyond simply presenting the life and work of an individual in some mutual relationship. It is clear that sometimes particular aspects of work can influence the development of an individual's life, and it is also clear that life events and their psychological repercussions can sometimes influence the direction of scientific work. Studying creative moments using biographical material on the relationship between life and work goes beyond such direct ideas of influence.

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