RELATIONAL PSYCHOPHYSICS – MAJOR MESSAGES FROM HERMANN EBBINGHAUS' AND MAX WERTHEIMER'S WORK

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Abstract

In past and modern research some main philosophical and methodological issues of human and animal perception have been discussed, with special emphasis on the relational basis of psychophysics. For example, the question has been raised if, and to which extent, there are viable bridges between traditional gestalt-oriented approaches and modern perceptual--cognitive work. Thereby the key concept of "frame of reference" is illustrated here by pointing to Hermann Ebbinghaus' classic geometric-optical illusions (cf. the Ebbinghaus-Titchener illusion), on the one hand, and Max Wertheimer's gestalt theory of the transposition phenomenon, on the other.

> "Some of the general philosophical principles guide research …, whereas others mislead them. As long as they remain tacit they are mere dogmas. Whereas such dogmas may be fertile, others are bound to be barren or even harmful to the search for truth and efficacy." - Mario Bunge and Rubén Ardila, 1987 (p. v)

Today there seems to be some renewed interest in the history and philosophy of psychophysics. In this paper I want to show that two former domains of perceptual-cognitive research remain relevant, at least from an epistemological and methodological perspective. Thereby the intertwined concepts of "frame-of-reference" (FR) and relational perception are the basis of some major work on geometric-optical illusions and transposition. In this context the interesting but intriguing question may be raised why it took so long, in the history of psychology, to coordinate ("bridge") the systematic analysis of the basic gestalt phenomena and psychophysical measurement (Sarris, 2004; Ehrenstein, Spillmann & Sarris, 2003; Sarris, 2006, Fig.1.1, p. 7; see below the section *Discussion and Prospect).*

Ebbinghaus´ law of relative size contrast

The unknown Ebbinghaus Besides his historic study of human memory the psychophysical analysis of some basic perceptual illusions was one of Hermann Ebbinghaus' core research issues. Thereby his work on optico-geometrical distortions (OGD, i.e. "frame of reference" illusions) is especially noteworthy. Indeed, Ebbinghaus was truly one of the first scientists who treated these phenomena systematically, in the second volume of his textbook *Grundzüge der Psychologie* ("Fundamentals of Psychology"; 1897-1913). Surprisingly, even the history books of psychology are silent on Ebbinghaus' important early OGD contribution (Sarris, 1986).

Ebbinghaus' OGD experiments and its systematic extension

When the reader consults Ebbinghaus´ eminent textbook, which was later praised to be one of the most important introductions to psychology, he gets familiar with his substantial studies of the horizontal-vertical illusion, the illusional decrement with the repeated presentation of

Ebbinghaus' divided-line pattern, the "transfer" effects for specific illusional figures, and also his experiments on the size-contrast function.

Ebbinghaus' law of relative "size contrast" Note that Ebbinghaus made a categorical distinction between "sensory contrast" and "size contrast" effects. In this connection he maintained that the size-contrast curve, as compared to the somewhat analogous sensory-contrast phenomenon (e.g., brightness contrast), does not follow a monotonic but rather a general inverted u-type trend. Thereby, relying also on the earlier findings stemming from some other researchers of his time, Ebbinghaus formulated the following general principle which I have called the "*Ebbinghaus' law of relative size-contrast*" (Sarris, 1986; see there Fig. 2, p. 141):

> "… The (size-) contrast effect reaches a maximum rather soon, but then it decreases comparatively quickly again. When differences are very large then every effect vanishes completely. Standing nearby dwarfs a man of medium height seems tall; near dolls …, however, he appears unchanged, i.e. you do not put him into any relation. Undoubtedly, for some of the above-mentioned patterns (not shown here) the size of a page of this book may have some moderate influence; but there is no such an effect if the patterns were drawn on a sheet of paper of (for instance) $^1/_8$ m^2 or ½ m^2. - (Ebbinghaus 1913, p.65; translation V.S.)

Note that Ebbinghaus' size-contrast experiment, although limited in empirical and theoretical scope, has been one of the first parametric studies ever done (cf. Sarris, 1986, Fig.4, p.146; Fig. 5, p. 148). Incidently, Ebbinghaus talked already of "… a kind of averaging formation", which is of general importance for the process of perception although the observer is hardly aware of it. Clearly, one should compare this anticipated "averaging" principle with the modern frame-of-reference concepts or models in psychophysics (e.g., Sarris, 1975, 2004, 2006).

Modern research - follow-up studies Elsewhere I have described some of the continuing research studies, for instance those by Frank Restle, Norman H. Anderson, and Stanley Coren which may now be seen as "follow-up" experiments of Ebbinghaus' original work. It suffices here to point briefly to the following model-related research as conducted in my own laboratory (see Sarris, 1986, 2006; cf. also Ehrenstein et al., 2003):

Sarris, with his research team, investigated three types of geometric-optical distortions (OGD), namely (a) some ideal *distance* or *gap* illusions, as for example the Delboef illusion; (b) a few ideal *extent* distortions, as for instance the Baldwin illusion or the Müller-Lyer illusion; furthermore (c) some *mixed-type* distortions - for instance, the classic Ebbinghaus illusion belongs to the third class, namely the "mixed" OGD type. Note that the distance (D) and the surrounding context-size (B) were systematically varied, together with the focus stimulus (X) to be judged. The systematic multi-factorial variation of these three major variables (B, D, X) gave experimental support as to the different kinds of illusions as predicted by Sarris´ (1986) mathematical, nonmonotonic, S-shaped contour-distance model. This line of research illustrated two main research strategies: (1) a gestalt-psychophysics approach based on a systematic multi-factorial design and leading to new quantitative and qualitative results, and (2) a type of research suggesting fruitful ideas as to the neurobiological mechanisms involved (e.g., Ehrenstein, Hamada, & Paramei, 2004).

Remarks:

One may well consider the Ebbinghaus OGD agenda as an important case in the history of psychophysics, providing us with the following messages:

- Classic gestalt phenomena are now to be investigated quantitatively on the basis of a psychophysical paradigm. Note that originally the quantitative parametric approach toward the OGD study was, more or less, *de*-emphasized by the gestalt school; and the scholars of psychophysics did not find it attractive to work with gestalt phenomena. This mutual neglect is nowadays conceived as a serious historical error.

- At best, modern OGD work is based on trendanalytical, multifactorial, and multimethod experimentation including the study of relational interactions *("configurality*"; e.g., Townsend & Pomerantz, 2004) between the respective perceptual-cognitive factors at hand (*testing-the-limits* approach).

- Nowadays the development and testing of predictive mathematical-computational models have become an indispensable methodology of acceptable research (Sarris, 1986; cf. also Wackermann, 2006).

Further desirable features of important modern OGD research, like comparative and neurobiological studies with different species, have been described elsewhere (Sarris, 2006, 2007; cf. also Oyama & Goto, 2007).

> "We shall advance our knowledge as far as ingenious minds will be capable to find out the means and ways. In fact, it is important to switch the attention on the substance of the issues at hand and not on their limits - only this will help us to progress. As long as the methods for some advancements were lacking, as a rule their solutions always seemed to be totally inconceivable and factually impossible. But as soon as these means were found out and became generally approved, again as a rule, one was surprised that such simple things could not have been discovered earlier." – (Ebbinghaus 1905, Vol. I, p. 98; translation V.S.)

Wertheimer's (mostly) qualitative account of transposition

Besides his research on apparent motion and gestalt patterns Max Wertheimer, in line with the work by Wolfgang Köhler (1887 – 1967), was also interested in the classic phenomenon of transposition (TP). This eminent gestalt principle refers to the fact that perceptual learning is relational (not absolute; cf. Sarris, 2001).

The neglected Wertheimer TP work In his paper on discrimination and generalization ("*On Discrimination Learning: Two Logical Structures*"), posthumously published almost half a century ago, Max Wertheimer (1959) made the point that *transposition* (TP) – a case of relational perception and memory – follows the major ideas of gestalt theory. In sharp contrast to the then prevailing Spence-Hull model of transposition he used several qualitative – partly even quantitative - illustrations to help explaining his own theoretical view, however without own data and without developing any precise mathematical model.

The gestalt phenomenon of transposition refers to the fact that perception preserves the relations between stimuli despite some crucial (large) changes as to the absolute stimulus values used. The study of transposition concerns the linkage of perceptual and mnestic processes as already exemplified in Wolfgang Köhler's classic work on transposition in chickens, apes, and children (cf. Sarris, 2001). For example, a monkey or a chicken is presented with two different sizes of squares, a smaller (A) and a larger one (B). After training to respond to B, the subject is tested over a period of time with a new pair of samples (say, B and C, where C is larger than B). Typically, the animal – or human - will choose C over B during the test phase. Mostly, this choice is based on relative rather than absolute stimulus properties, thus showing "transposition" (TP) which is considered as a special case of frame-of-reference effects.

Modern TP research - comparative psychophysics

As described elsewhere, a large body of comparative *TP* psychophysics has been established in my laboratory - namely (see Sarris & Hauf, this volume): In a series of *uni-dimensional* experiments increasingly larger volumes or decreasingly smaller ones were used in some other studies the same chickens were trained and tested under all contextual conditions (*testing-the-limits*). In all cases the different test series provided the crucial role of contextual stimuli. As predicted by the mathematical model (Sarris, 2004, pp. 77-79; 2006, pp. 33-35) the chickens showed marked contextual effects during testing thus conforming to a large body of findings in human psychophysics. Note, however, that during the first test trials, these animals reacted to the stimuli as if they still belonged to the given training-stimulus pair (*no* context effect); i..e. only gradually, over the next series of test-trial stages, the chickens "shifted" their responses towards the new contextual test series (cf. also Russell & Kirkpattrick, 2007).

This unidimensional paradigm has been extended to a *multi-dimensiona*l approach (Sarris, 2004, 2006). A simple example illustrates the multidimensional problem of relational psychophysics: Everybody knows that jockeys are usually "small" and basketball players "large"; at the same time we are able to judge an individual jockey as "large" and a basketball player as "small". But how do we develop such internal frame-of-reference systems – and, are birds and humans able to perform a two-dimensional psychophysical task such as this in a similar manner? As a matter of experimental fact, the results of this kind of research also showed typical relational features in that one and the same stimulus elicited very different responses depending on the given context-test stimuli used. Surprisingly, some rudimentary lawful TP effects have been also found in the baby chicken (Sarris, 2006, 2007: "*awaking cognition*").

Remarks:

In my opinion Wertheimer´s original theorizing plus the foregoing modern TP ("frame-of-reference") research extensions are an important case of serendipity in the history of psychophysics, with the provision of the following major messages:

- Trendanalytical experimentation: Such kind of research makes systematic use of the "testing-the-limits" approach in psychophysics.

- Mathematics of TP – quantitative model building: It is important to develop and test precise quantitative transposition (TP) models; this may greatly help to "bridge" the fundamental gestalt phenomena and psychophysical methodology.

- Multifactorial TP analysis: A special virtue of modern experimentation is based on the simultaneous consideration of two, three, or even more perceptual-cognitive factors at hand thus leading to the discovery of emergent "interactions" ("configural" patterns).

- Developmental psychophysics of comparative TP research: This kind of research is devoted to the better understanding of the dynamic processes underlying the phenomenon of "transposition" (e.g., the memory processes involved).

In addition, the relevance of the complementary investigation of the neurobiological processes ("correlates" resp. "substrates") – for instance, as to *grouping* and *segmentation* - underlying these various, quite heterogeneous TP findings can be hardly overstated (cf. Sarris, 2006, chaps. 5 & 6).

Discussion and Prospect

The fundamental role of phenomenology may, nay should, be seen as the main basis of the – somewhat interrelated - messages derived here from Hermann Ebbinghaus' and Max Wertheimer's pioneering work. The significance of "phenomenological" thinking for the past and future of psychophysics is secured and at least implicitly assured also in animal psychophysics (like in all comparative or infant psychophysics), and it must not be downgraded as being a more or less "cheap" byproduct of philosophical reasoning. Indeed, phenomenology needs to be stressed also in the comparison of all human and animal data analysis notwithstanding the fact that the perceptual-cognitive animal responses as well as the human infant reactions rely necessarily on *indirec*t, i.e. *behavioral* observations resp. measurements (see below: *explanatory gaps*).

Difficulties in psychophysics. In the different fields of psychophysics, including the case of relational psychophysics, we are facing several substantial problems – namely:

- Explanatoray gaps: There are three epistemological, explanatory gaps in all psychophysical work; they refer to the three categorically different levels of (a) the subject's phenomenal appearances, (b) her or his corresponding neurobiological processing, and (c) the scientist's computational or mathematical analysis of lawful stimulus-response relationships (cf. Sarris, 2006, Fig. 1.1, p. 7).

- Enduring "cog" issue: The growing development of cognitive ("cog") psychophysics has broadened and enriched this domain enormously but, at the same time, greatly complicated its theory and model building (consult my multistage-process model of perceptual-cognitive functioning: cf. Sarris, 2006, Fig. 5.1, pp. 77-80).

- Language barriers: Until today the scientific working "languages" as used by the different psychophysicists – namely, sensory scientists, cognitive psychologists, neurophysiologists, bioengineers, and computer scientists - are quite difficult to convert into another. Optimistically, the nobel-prize winning neurobiologist David Hubel, who recently made this observation, feels that the respective scientific barriers will be gradually overcome (cf. Ehrenstein et al., 2003; Sarris, 2006, 2007).

> "Yet a knowledge of history of science is important. It gives perspective. It aids humility. It exhibits the kinds of errors that can be avoided. It even saves the trouble of discovering the same fact twice." - Edwin G. Boring, 1942 (p. 613)

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