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PSYCHOPHYSICS PHENOMENOLOGIZED? SENSATION AND DECISION IN VISUAL MOTION PERCEPTION

abstract

Experimental phenomenology and psychophysics are two rather different approaches to the study of perception, and rely on first-person descriptions and third-person measurements of the percept, respectively. Yet, a common ground may be found in the original goal, shared by both approaches, of addressing the conscious dimension of perception. Here we argue that, despite being objective and quantitatively-oriented, psychophysics can, with some cautions, recover certain simple subjective aspects of conscious perception. Building upon the results of a motion perception experiment, we show how to transform the ratings of subjective visibility into a well-known index of objective discriminability in perceptual decisions (d'). We found that, once all factors are equated, motion discrimination is superior to motion detection, as measured as perceptual decisions; in turn, motion detection is superior to subjective motion visibility. This finding strengthens our previous suggestion that, under uncertainty conditions, perceptual decisions can be taken before the conscious percept is fully stabilized, and suggests that some simple sensations can be reliably captured by objective “currency” through an open-minded quantitative approach. Our perspective may be regarded as an attempt to “phenomenologize psychophysics”.

keywords

Sensation, decision, perception, consciousness

It is generally accepted that psychology as a scientific discipline originated in 1879, when Wilhelm Wundt founded the first laboratory of experimental psychology in Leipzig. Mental facts were thus thought to be explained by physical/physiological facts, and assumed to be amenable to experimental investigation, as in the physical/physiological sciences. These ideas were then exported in the United States by Edward Titchener, and became a main tenet of the mainstream scientific psychology. The reliance on the scientific method in psychology also heavily drew from a new discipline that had emerged just a few years earlier, also in Germany: Building upon the pioneering work of Ernst Weber (1834), Gustav Theodor Fechner published in 1860 his *Elemente der Psychophysik*, which established psychophysics as the quantitative branch of the study of perception and the “exact science” of the relation between sensory stimuli and the ensuing sensations (the so-called external psychophysics). At variance with Wundt’s methodology, which involved controlled introspection to characterize the subjective sensations of his subjects, psychophysics developed its own rigorous methods to measure sensations,¹ introducing for example the notion of sensory thresholds. About one century after Fechner’s initial work, the application of Signal Detection Theory (SDT), originally developed for telecommunications, brought an important evolution in psychophysics, shifting the focus on the capability to make a perceptual decision² (e.g., deciding that a given signal, or stimulus, is present or absent). Another important extension of psychophysics came with the introduction of the scaling methods, which assumed that subjects can produce reliable quantitative reports of their own subjective sensations (Richardson, 1929; Stevens, 1946, 1957). In direct magnitude estimation, for example, subjects are asked to assign a numeral to a given sensory attribute along a continuum, or scale.

In the same period of Wundt, and again in Germany, Franz Brentano gave rise to another school of thought in psychology, grounded on phenomenology rather than on experimental science. Brentano did not believe that psychophysics could really get a grasp on the structure of

1 With the term “sensation” we do not mean the introspective reading of an internal event, nor just the processing of sensory information, but the humble conscious experience of an external stimulus.

2 A perceptual decision is the result of choosing an option from a set of alternatives based on available sensory information.

conscious experience, which in his opinion should be demonstrated through direct experience rather than measured: “a clear understanding of what is actually measured by Fechner’s methods would show us that the object of measurement is not so much a mental as a physical phenomenon” (Brentano 1874/2009, 52). However, immediately thereafter Brentano himself seems to leave room for the possibility of measuring mental facts through psychophysical methods, though only partially: “For my part, I admit that if, on the basis of Fechner’s method, a measurement could be found for the physical phenomenon, it could also be found for the mental phenomenon in which the physical phenomenon is presented. Yet, it seems to me necessary to add the new restriction that only one aspect of the mental phenomenon should be measured according to its intensity, namely its reference to its primary object, for we shall see that the mental phenomenon has still other aspects and is not exhausted by this one reference” (p.52). The ideas of Brentano have been highly influential for Edmund Husserl in philosophy, and Carl Stumpf and Alexius Meinong in psychology. Later on, the Berlin school of the Gestaltpsychologie (Wolfgang Kohler, Kurt Koffka, Max Wertheimer) sprouted from the phenomenological tradition. In Italy, Cesare Musatti, Fabio Metelli and Gaetano Kanizsa, following Vittorio Benussi, contributed crucially to the diffusion of the phenomenological method in psychology.

Behind the substantial differences between the psychophysical and the phenomenological approach to the mental facts, they share the original aim of grasping the realm of subjective experience, at least in the domain of perception. As a matter of fact, Fechner embraced a view of the mind-body problem (“psychophysical parallelism”) that at least certified his genuine interest for the mind. While the primary concern for conscious perception remained obviously well alive in the phenomenological approach, also in its experimental variant (Bozzi, 1989; Vicario, 1993), it remained somewhat under the surface in the psychophysical approach, where observers were better regarded as “responding machines” (producing an observable behavior) rather than “contemplative spectators” (having a private sensation). Indeed, perceptual decisions can be studied disregarding the phenomenal status of the observer.

The risk of throwing consciousness away is present also in cognitive neuroscience (with some notable exceptions, e.g., Gallagher 2007; Gallese 2006; Varela 1996). Because neglecting the conscious mind cannot be adequately motivated by the need to reject metaphysical dualism, as this

would throw the baby out with the water (de'Sperati, 2006), consciousness must be taken seriously. However, if neuroscience aims to address the conscious mind, either it undergoes a Kuhnian revolution, or it cannot escape the traditional logic and methodology of experimental investigation, the same that has always been used for studying, say, movement and neural motor control. This in turn implies that appropriate methods to measure the conscious experience should be adopted, and this brings back to the target theme of this article. In this regard, we just note that the terminology is often loose or ambiguous, as, for example, studying visual perception is not tantamount to studying the conscious experience of seeing, although it clearly alludes to it. More generally, this is the difficult relation between consciousness and cognition. The ambiguity is certainly not dissipated by presenting physiological and neuroimaging methods as methods to measure the mind (Senior et al 2006). Somewhat ironically, the formulation “neural correlates of consciousness” (but, again, also “neural correlates of movement”) implies the existence of two terms.

In this article we will not try to refute or favor one or the other approach, phenomenology or psychophysics, as this is probably an endless exercise.³ We simply wish to underline some aspects that we hope may help appreciating the efforts that at least part of the scientific psychology community puts in the attempt to get close to the conscious, subjective experience, simple as it may be, without throwing it away but rather taking it seriously (Overgaard, 2001). Although a defining property of the experimental method is the manipulation of the independent variable(s), we will deal with another important aspect of the scientific method, that is, the choice and the treatment of the dependent variable(s). In particular, we will focus on how to (try to) measure a conscious sensation in visual perception using the tools of psychophysics. For this, we will build upon a recent study on motion perception (Gregori-Grgič *et al.*, 2011), as well as on some data of a new experiment in which various tasks and conditions are directly compared, which differ along the objective/subjective dimension (though this distinction is somewhat blurred in psychophysics, Kingdom & Pins 2010).

Briefly, we used noisy motion stimuli (RDK, Fig. 1A), which were presented

³ In 1932, a committee appointed by the British Association for the Advancement of Science to answer the question whether human sensations could be measured, took seven years to discuss the issue and did not reach a general consensus (Michell, 1999).

for 200 ms to 18 observers. Before running the main experiment, we selected the individual 75% coherence threshold, so to make motion difficult to discern. The “motion” stimuli were randomly alternated to the “noise” stimuli (coherence=0%). The observers had to tell whether the stimulus was motion (regardless of its direction) or noise by a key press (detection task). Because there was only one stimulus in each trial, the above trial design is called 1-Interval (this kind of detection task is also called yes/no task). We used also another design, called 2-Intervals, in which two subsequent stimuli are provided in each trial, either the pair rightward/leftward motion or the pair motion/noise. This time the observer had to tell in which interval (first/second) was the motion or the noise stimulus (detection task, 2-Int), or in which interval (first/second) was the rightward or the leftward stimulus (discrimination task, 2-Int). Because the dimension of the response (first or second) is independent of the stimulus content, this design is often considered to be more objective and unbiased as compared to the yes/no task. Finally, in another session observers had to judge the subjective visibility of motion, with the stimulus presented with a 1-Interval design, as detailed below (detection task, 1-Int Rating). Two aspects were crucial.

Firstly, in order to capture as much as possible the first-person, subjective visibility of motion (the conscious sensation), we used an absolute 5-points rating scale (“perceptual awareness scale”, Overgaard *et al.*, 2006). Subjective visibility is thus assumed to be a prothetic, rather than a metathetic continuum. The number of points was chosen to make the scale simple and comfortable for the observers, and the extremes of the scale were anchored to the minimum and maximum absolute values, namely, null visibility and full visibility. Then, despite not strictly necessary (see below), we ensured that participants understood that the scale represented a linear quantity.⁴ The instructions, which were given in both written and colloquial form, were the following: 0 = You didn't see at all the motion direction; 1 = Between 0 and 2: you had a raw feeling of the motion direction; 2 = Half-way point of the scale: you probably saw the motion direction; 3 = Between 2 and 4: you saw the motion direction, but not too well; 4 = You saw clearly the motion direction.

Secondly, because it is important that the measures of sensation are expressed in a “currency” suitable to be directly compared with the

⁴ Another solution could have been to use a Visual Analog Scale, which is continuous. However, because of the properties of the ROC curve, the same results would be expected.

“objective” measures of perceptual decisions (Reingold and Merikle, 1988), the visibility ratings were transformed into the so-called sensitivity index d' , which measures the discriminability of a signal in decision tasks (Wickens, 2002). Briefly (for details see Gregori-Grgic *et al.*, 2011), the rating task was treated as a multiple detection task: the scores greater than 0 were first considered to be ‘motion’ responses, while the 0 score was considered to be a ‘noise’ response; next, scores greater than 1 were considered to be ‘motion’ responses, while scores less than 2 were considered to be ‘noise’ responses, and so on, until encompassing all pairs. Following SDT (Wickens, 2002), hits (‘motion’ | motion) and false alarms (‘motion’ | noise) were computed. The pattern of hits and false alarms allowed us to build a ROC curve, from which d' can be derived (area theorem). Thus, a subjective judgment about motion visibility was transformed in a standard quantity (d'), which is a useful common “currency” in psychophysics and has a well-known metrics.

This second aspect is important not only because it provides an index with a common metrics, but also because it allows to avoid a thorny issue in psychology, namely, that of the scale of measure. Clearly, it is always desirable that a measure preserves all the properties of the phenomenon it represents, as in physics, where measures are quantitative. However, in psychology this is not always strictly required, and many scales are in fact used (nominal, ordinal, interval, ratio), at the cost of losing progressively certain properties: passing from the nominal scale to the ratio scale, one passes from a purely qualitative measure to a fully quantitative measure, and gains identity, order, quantity, and absolute value, as well as an increasing number of allowed mathematical and statistical treatments of the variable. Clearly, more stringent positions exist, and according to Lord Kelvin, “When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of science”. A similar view was expressed by the Pythagorean-style Thorndike’s motto “whatever exists at all exists in some amount”. With our particular data analysis there is no need that the points along the ROC curve are equally spaced, thus there is no need that the raw visibility ratings represent necessarily an interval or ratio scale, which is always a questionable assumption. In fact, by using the ROC curve we could build a fully quantitative index out of an ordinal variable, without assuming that observers are capable

of translating faithfully a conscious sensation into a number.

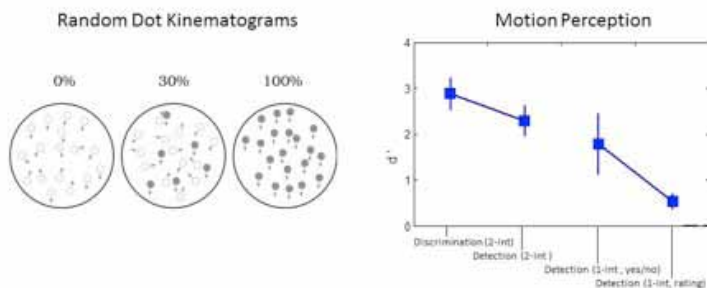


Figure 1. Left, the visual motion stimuli (RDK) with three different coherences. In the actual experiment, we used only the threshold coherence and the zero coherence; also, all moving dots had the same color. The stimuli were briefly displayed for 200 ms. Right, motion perception performance under different conditions, expressed in the same metrics (d'). The insets indicate the statistical significances. Bars represent the standard deviation.

Figure 1B illustrates the main results of the experiment. All relevant differences can be appreciated: Discrimination is superior to detection, when assessed with a 2-Intervals trial design ($p=0.007$). Despite being a somewhat counterintuitive result, this is not a fully unexpected effect, its magnitude depending on the relation between the sensory attributes used for detecting or discriminating a stimulus (Wickens, 2002). The yet non-significant superiority of 2-Int detection compared to 1-Int detection is also expected, and depends on the additional information provided by two stimuli, compared to one stimulus (Azzopardi&Cowey, 1997). Finally, the lowest performance was observed in the rating task, in which d' was significantly lower than in the yes/no task ($p=0.048$).

Why d' was so low in the rating task? We argue that it is because this task implies a fully conscious judgment, whereas a simple 1-Int detection task, and even more so the 2-Int detection task, can be executed automatically or almost automatically (for example with less attention), especially with simple and repetitive stimulus presentations in the laboratory. This implies that an observer can detect the motion stimulus even when it is subjectively invisible, as also suggested by a large body of data on

unconscious perception (Merikle *et al.*, 2001). Consider also that monkeys can be trained to perform a sort of yes/no task (the so-called commentary key method, Cowey and Stoerig, 1997), but it is doubtful that they can be trained with a complex rating task. Obviously, these considerations do not imply that human observers perform detection tasks always automatically, or that monkeys are phenomenally blind; they just indicate that a rating task for subjective visibility is more likely to tag visual consciousness than other detection tasks. Thus, the perceptual performance, be it detection or discrimination, can be higher than expected on the basis of the reported subjective motion visibility. This, in turn, strengthens our proposal that, at least under uncertainty conditions, conscious perception lags visuo-motor responses and perceptual decisions (de'Sperati and Baud-Bovy, 2008; Gregori-Grgić *et al.*, 2011). In other words, perceptual decisions can be taken before the observer achieves full conscious appreciation of the stimulus.

Even though our proposal of transforming the subjective visibility ratings into a measure of perceptual decision seems to be a useful link between first-person and third-person aspects of perception, the first step of our procedure, namely, the very assessment of the subjective sensation itself, may not be totally undisputed. Despite the careful instructions to the subjects, the mainstream, orthodox Gestaltist might not be satisfied using a scale to describe a subjective sensation. He might object that the procedure is still somewhat constrained, that the conscious subjective experience cannot be reduced to a simple score, and that the relation between the scores and “true” visibility would be anyway largely arbitrary, so that the idea that a scale captures the conscious experience is something closer to wishful thinking than to a granted fact. Indeed, this is not exactly what the Gestalt phenomenological tradition hoped to get, that is, “as naïf and full a description of direct experience as possible” (Koffka 1935): After all, the perceptual judgments that we asked to our participants were neither truly “naïf” nor “full”.

But even the mainstream, orthodox psychophysicist might not be fully satisfied either, although for different reasons. He would claim that a rating scale is not enough objective, and would prefer to use quantities derived from more constrained procedures involving for example forced-choice responses. Fechner himself – but not Stevens – did not believe that subjects could directly judge the quantitative structure of their sensations (Michell, 1999, 82). Some recent proposals also addressed the hard problem to combine

the objectivity of a measure of perceptual decision with the subjectivity of individual experience, but without assessing directly the perceptual sensation. Post-decision wagering (Persaud *et al.*, 2007), as well as the simpler method of confidence rating (Kunimoto *et al.*, 2001), involves subjects taking a decision about a given stimulus attribute (e.g., rightward or leftward motion), and then placing a bet on their own decision, or simply giving a confidence rating. By properly combining the decision and the wagering/confidence responses, it is presumed to construct a reliable measure of the conscious experience of the stimulus that originated the decision. The title of the original paper is instructive in this regard (*Post-decision wagering objectively measures awareness*; but see Evans and Azzopardi, 2007 and Sandberg *et al.*, 2010 for less optimistic views). Here too, and perhaps even more convincingly than in a simpler rating task for visibility as the one we have used, automatic evaluation can be excluded, and conscious judgment implied. However, whereas adding metacognition to a perceptual task would grant the involvement of consciousness, it would at the same time tax the procedure with extraneous elements (in the case of confidence rating or post-decision wagering it is the estimation of the confidence of an internal decision, not of stimulus visibility). Unfortunately, where exactly drawing the line between a simple conscious sensation – something to be preserved – and additional metacognitive processing – something to be excluded – is not at all obvious. As a matter of fact, the act itself of reporting, even in the most natural way, a conscious sensation is already adding an extra-load. Although no single measure of consciousness (but not even verbal descriptions) escape this rule, we believe our rating of subjective visibility is closer to the raw subjective sensation than any measure of perceptual decisions, whether or not combined by a self-evaluation of the decision reliability.

A few years ago Vittorio Gallese maintained that we should “phenomenologize cognitive neuroscience rather than naturalize phenomenology” (Gallese 2006, 294). In this vein, our attempt may be regarded as a first step towards the “phenomenologization of psychophysics” (Kubovy&Gepshtein, 2003). Probably, the orthodox Gestaltist would continue to assert the primacy of the phenomenological analysis, while the orthodox psychophysicist would probably continue to prefer more objective procedures. We have no answers to convince orthodox believers, but we hope at least to have offered some arguments to heterodox agnostics. Clearly, our proposal lays entirely within the psychophysical tradition, but the line is drawn close to the subjective side of perception. In doing this, we

have merged the spirit of subjective direct scaling (magnitude estimation, Stevens, 1957), with the spirit of objective decision-making (SDT, Wickens 2002). While there is no doubt that the richness and the structure of our conscious visual experience goes well beyond a measure of the level of a single quantitative attribute, we think it is important to try to go at the heart of conscious experience itself, which we have identified as subjective visibility. Focusing on the very origin of the conscious sensation (the “first half second” in the microgenesis of perception, Ogmen and Breitmeyer, 2006) may be a unique opportunity, if not a requirement, to understand how visual consciousness emerges out of sensory-motor mechanisms.

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