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Chapter 38

"Judgment" vs. "Response": A General Problem and Some Experimental Illustrations

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Sometimes a theoretical problem becomes apparent when two different research traditions meet within the same empirical field of investigation. The meeting ground that we are concerned with in this paper is visual backward masking. The two experimental traditions are sensory psychophysics and information processing research. The problem that their encounter elucidates -or at least one of the problems that it sheds light upon -- regards the concepts of "judgment" and "response".

First we describe the two research traditions, one of which was initiated under the direct influence of Gustav Theodor Fechner. Next we discuss some possible conceptualizations of the relationship between judgment-based and response-based research into visual backward masking. Finally, we present some data that suggest one particular view of this relationship, viz. that they represent mutually complementary, but not necessarily converging, operationalizations of backward masking.

Judgment-Based Research on Backward Masking

The concept of judgment is central to Fechner's psychophysics. At the beginning of chapter 8 of the "Elemente der Psychophysik", Fechner (1860/1964) discusses which kinds of measurement are required by psychophysics, and then goes on to say:

> "*Die Ausführung des Masses auf Grund dieser Bestimmungen setzt voraus, dass wir die Gleichheit von Empfindungen und Empfindungsunterschieden unter verschiedenen Umständen wirklich genau zu beurtheilen und zu constatiren vermögen*" (Putting into practice the measure(ment) on the basis of these designations presupposes that we are indeed able to exactly judge and state the equality of sensations and of differences between sensations under various circumstances). (Fechner, 1860, p.70)

Thus, the subject in a Fechnerian experiment had the double task of first observing his sensations (introspection) and second of judging them (making an introspection-based decision).

Research on visual masking began within this methodological framework. The first masking experiment was published only eight years after Fechner's "Elemente der Psychophysik". The author was Sigmund Exner, then a medical student in the laboratory of Herrmann von Helmholtz (Exner, 1868). Later on, Exner became a professor of physiology himself, and still later his career led him into the Austrio-Hungarian Ministry of Education at Vienna, where he was one of the favorite targets of attacks by Karl Kraus (e.g. Kraus, 1900, 1901, 1903, 1907).

As Henri Piéron (1914) has noted, Exner was probably influenced by Fechner's book when he proposed a version of the logarithmic law to account for his data: According to Exner, if stimulus intensity grows in geometric progression, then the time needed for the sensation to reach its maximum (*Maximalzeit*) will grow in arithmetic progression. This possible influence of Fechner on Exner's theorizing is interesting, but more relevant to our present topic is Fechner's influence on Exner's method.

Exner worked with a very cleverly constructed and very precise tachistoscope, in which he could present a lighted semi-disk, followed by a lighted complete disk, followed by a dark interval. Using exposure durations between 14.5 and 19.3 msec for the first stimulus (in those days measurement was to the tenth of a millisecond!), Exner found that this stimulus became invisible when the second stimulus had a minimum duration of between 118.8 and 287.3 msec, depending on luminance.

Exner did not use the term "masking" for this effect. In fact he did not recognize that the second stimulus interfered with the perception of the first. (This was realized only almost half a century later by Exner's student Rudolf Stigler [Stigler, 1910]). Exner's interpretation was that the apparent disappearance of the first stimulus was due to the time course of visual sensations. In this he was wrong, but he had discovered visual backward masking.

He had discovered it by a strict application of Fechnerian methodology. By means of what was subsequently called the ascending and descending method of limits, Exner determined the mask durations at which the test stimulus became just invisible or just visible. (Incidentally, Fechner [1860/1964] himself did not use the term "method of limits." His name for this method was "Methode des ebenmerklichen Unterschieds" [method of the just noticeable difference]).

Exner's work was at the beginning of a research tradition that has been continued until the present. The psychophysical style of investigating visual backward masking was taken up and further developed by researchers such as Stigler (1910), Piéron (1914), Fry (1934), Werner (1935) and Alpern (1953) and is still flourishing (e.g. Reeves, 1982; for a review see Breitmeyer, 1984). The methodological characteristics of this line of research have remained remarkably uniform since the pioneer work of Sigmund Exner: A very precise control of stimulus parameters (in modern research with the help of devices such as an artificial pupil and a Maxwellian view); a small number of highly trained observers, usually including the experimenter himself; and careful judgments by these observers that provide the raw data for constructing, e.g., threshold functions.

Response-Based Research on Visual Backward Masking

Almost a century after Exner's discovery, visual backward masking was rediscovered within the research context of what was to become a powerful and influential movement, "Information Processing Psychology." Both George Sperling in his dissertation (Sperling, 1960) and Averbach and Coriell in independent work that was published one year later (Averbach & Coriell, 1961) were interested in the processing of briefly presented letter sequences.

Let us have a look at the work of Averbach and Coriell (1961). They were among the first investigators that used a television monitor to present their stimuli, two rows of 8 letters each. The subject's task was to report one of these letters, designated by a cuing stimulus that was either a bar marker or a circle indicator and that appeared at various temporal positions before or after the letter array. One of their discoveries was that the circle indicator reduced performance at certain delays, particularly around 100 msec; i.e. the number of letters reported correctly was much less than with the bar marker. Thus, they had rediscovered visual backward masking and more specifically metacontrast, a variant that had first been described by Stigler (1910).

Since Averbach and Coriell (1961) were unaware of this previous psychophysical research, they had to invent a new name for their masking effect, "erasure". In a way, this renaming was not unjustified, since there are many obvious differences between Averbach and Coriell's method of assessing erasure and the classical backward masking experiment in the tradition of Exner (1868).

The difference that deserves a closer examination in our present context concerns the subject's task and the dependent measure. Averbach and Coriell's subjects neither had to observe nor to judge anything. As the authors put it "The subject's task is to name the letter designated by the marker" (Averbach & Coriell, 1961, p.311). If the subject felt he could not do this – that is, if he was uncertain about the letter's identity –, he had nevertheless to come up with some answer, guessing the letter's identity if necessary.

Thus, Averbach & Coriell's subjects were not asked about their sensations or perceptions, but about the letter that was in fact presented. They were not required to carefully judge introspective evidence, but to be as good as they could in terms of percent correct, using any kind of information that they had at their disposal. They were required to produce a correct response, not to give a valid judgment.

This style of experimentation – using naive subjects, giving them a task that can be assessed objectively, and using a performance score (percent correct and/or response latency) as the dependent measure – has become a standard in present-day investigations of visual backward masking. Although there have been a few attempts in the early days of information processing research on backward masking to use subjective judgments in addition to performance measures (e.g. Liss, 1968; Haber & Standing, 1968), the methodological gap between the two traditions, judgment-based and a response-based research on visual backward masking, is fairly obvious.

Judgment vs. Response

How do the two methods relate? One possible answer is both trivial and unproductive, and therefore, we shall mention it only briefly: Some investigators from both fields would probably argue that their own approach is simply the correct one, whereas the other is outmoded or inadequate. Proponents of objective performance measures tend to view subjective psychophysics as a residual of unscientific introspectionism; whereas researchers who are used to the rigorous standards of psychophysics sometimes feel that putting a naive subject in front of a computer monitor and giving him a task that he is allowed to solve by any strategy that he happens to invent can provide only the crudest kind of data, especially in combination with the less than perfect control of parameters such as stimulus luminance and retinal locus that is typical of this kind of research.

If one does not resort to this kind of methodological solipsism, then there seem to be essentially two further, more interesting, answers to the question of how the two styles of research are related.

First, it might be that they provide converging operations for the same inferred internal process. Perhaps it is one and the same effect of a visual mask that is assessed by psychophysical judgments and by responses in an information-processing task. Possibly it is nothing more than a matter of convenience whether we ask the subject to observe the stimulus display and record his judgment about, say, apparent brightness, or whether we have him perform a letter identification task and record response latency and/or percent correct. Since both methods have their advantages and shortcomings, it would in this event be desirable to use both in conjunction, or at least to combine results from both for theory building.

The alternative possibility is that such a convergence does not exist, or is partial at best. It could be that the conscious representation that a psychophysical judgment refers to and the processing operations whose efficiency shows up in response accuracy and response latency measures are not necessarily correlated. In this case, we would again want to consider both kinds of data. The aim, however, would not be to merge them, but rather to contrast them. Perhaps this will provide us with insights into the functional architecture of the processing system and, more specifically, into the place and function of conscious representations within the system.

The possibility that judgment and response are not necessarily correlated seems indeed plausible, if one takes into account data from fields other than visual backward masking (see Neumann, 1989, for a review). To mention just two examples from the recent literature: Bridgeman, Kirch and Sperling (1981) had their subjects judge the position of a visual target and, in addition, respond manually by pointing to the target. When illusory motion was induced by means of a surrounding frame that jumped back and forth, this had a strong effect on position judgments, but pointing performance remained largely unaffected. Similarly, McLeod, McLaughlin and Nimmo-Smith (1985) have shown that manual performance in hitting a falling object is far superior to visual-coincidence judgments.

In the backward masking literature, dissociations between judgment and response have allegedly been demonstrated under headings such as "subliminal perception", "preconscious processing" or "unconscious perception" (e.g. Dixon, 1971, 1981; Marcel, 1983). Unfortunately, this line of research has been hampered by methodological problems ever since it started in the 1950s (see, e.g., Eriksen, 1960; Cheesman & Merikle, 1985; Holender, 1986). There are, however, other examples that do not suffer from these methodological difficulties. We will briefly describe two sets of results from our research.

Two Experimental Examples

Both examples point to a dissociation between judgment and response in metacontrast. As mentioned, this is a special kind of visual backward masking in which the mask is presented laterally adjacent to the test stimulus; e.g. the target is a disk and the mask is a surrounding ring or a larger disk.

The first example is the Fehrer-Raab effect. As first reported by Fehrer & Raab (1962), the latency of a simple key-pressing response (a-reaction) is unaffected by metacontrast masking, even if the target is completely obliterated by the mask, as assessed by the subjects' judgments. This effect has often been replicated in subsequent research (see Neumann, 1982, for a summary). At first glance, it seems to demonstrate a clear-cut dissociation between judgment and response. We became interested in it, however, because we were skeptical about this conclusion, which seems to imply that, counter-intuitively, the target can trigger a voluntary response although the subject does not consciously perceive it.

Our skepticism was based on a closer examination of the effect, which indicated that the standard finding as such does not yet provide any conclusive evidence. The reason is that the judgment is about detectability, brightness or some other non-temporal dimension, whereas it is, of course, latency that is reflected in reaction time measurement. Hence there is a logical possibility to explain the effect without implying any dissociation between judgment and response. All that has to be assumed is that the masked target reduces not only response latency, but also the latency of the subjective perception of the mask. In this case the Fehrer-Raab effect would occur even though the subject reacts not to the masked target, but to the mask. The reason why the masked target speeds up the processing of the mask could be that it acts as a kind of pacemaker that prepares the system for the processing of the mask. In fact, our model of masking predicts this to happen ("weather station model"; Neumann, 1979, 1982; Neumann & Müsseler, 1989).

If this is the correct explanation of the Fehrer-Raab effect, then the apparent dissociation between judgment and response should disappear if we ask the subject the right question, viz. not whether the target was detectable, but when the mask appeared. According to the hypothesis, the reduction in response latency that constitutes the Fehrer-Raab effect should be accompanied by a corresponding shift in the apparent temporal position of the mask.

This can be assessed by temporal order judgments (Cazin, 1981; Neumann, 1982). We presented subjects with two identical disks, one to the left and one to the right of fixation. One of the disks served as the standard. The other – the comparison disk – appeared either alone, or it was preceded by a smaller disk that was, however, masked by it. The task was to judge which of the two visible disks (the standard or the comparison disk) appeared first. As predicted, the masked target caused a systematic displacement of the psychometric function. The larger the SOA (Stimulus Onset Asynchrony) between the target and the comparison disk that masked it, the more the comparison disk appeared shifted forward in time relative to the standard.

In a further experiment we measured the Fehrer-Raab effect, using exactly the same experimental conditions (Neumann, 1982; Rosengärtner, 1980). The result was equally clear-cut, but disappointing from the point of view of the hypothesis under investigation: The reduction in response latency was consistently larger than the shift in the judged temporal position of the mask/ comparison stimulus. The data indicated that roughly half of the amount of the Fehrer-Raab effect can be accounted for by a shift in the apparent temporal position of the mask, but the other half cannot.

Hence the dissociation between response and judgment has survived our test. Judgment and response are both influenced by the masked target, but differently. Clearly, the response does not depend on the judgment.

The second example leads to essentially the same conclusion. It concerns an effect in metacontrast masking that we discovered several years ago, using a small black disk as the target and a surrounding ring as the mask (Neumann, 1979): If a target-mask sequence is presented to the left or right of fixation, and a second stimulus identical to the target – a distractor – is presented contralaterally, then the U-shaped masking function will be changed in a characteristic manner: While the descending part of the function remains unaffected, the ascending part is shifted towards longer SOAs due to the presence of the distractor.

This has been found reliably in several studies with a judgment task, using the method of constant stimuli (Neumann, 1979; Aufschläger, 1979) and the signal detection method (Adler, 1979). To our great surprise, this distractor effect disappeared, however, when we switched from judgment to response. In one experiment, we used four different variants of the target (disks slightly truncated on different sides), between which the subject had to discriminate in a forced-choice decision task. Though the experiment was identical to the previous ones in all relevant aspects, the distractor effect vanished (Milewski, 1980; Figure 1).

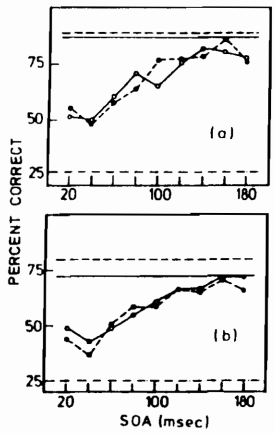

Figure 1. Percent correct forced-choice responses in a task in which 6 subjects had to decide on which side (left, right, bottom, or top) a target disk was slightly truncated. Abscissa: SOA target-mask. Open circles: no distractor. Filled circles: with distractor (an untruncated disk of the same size as the target). Horizontal lines: Data from a control condition without mask. The two panels represent two levels of difficulty of the task (b = very slight truncation, a = more pronounced truncation). (Data from Milewski, 1981).

In recent experiments we have replicated this result with other stimuli. Subjects had to discriminate between two arrowheads, that pointed either to the left or to the right and that were followed by a mask that consisted of two overlapping arrowheads. Performance was not reliably affected by any of the distractors used in this experiment (an arrowhead identical to the target, an arrowhead pointing in the other direction, or a disk of similar size; Figure 2).

Those who believe in "hard" response measures will probably interpret this as a proof that the subjective judgment method is flawed. However, we have no reason to regard the earlier results as invalid. To check for possible artifacts, we have recently replicated and extended the earlier research with the disk-ring paradigm. Instead of a small number of experienced observers, we used a large group of naive subjects. There were two different distractors, either a disk identical to the target or an arrowhead. Further, two groups of subjects received two different instruction that stressed either careful observation or fast, "automatic" responding. The task was always to judge whether the target was present. There was a highly significant distractor effect in all conditions, as can be seen in Figure 3.

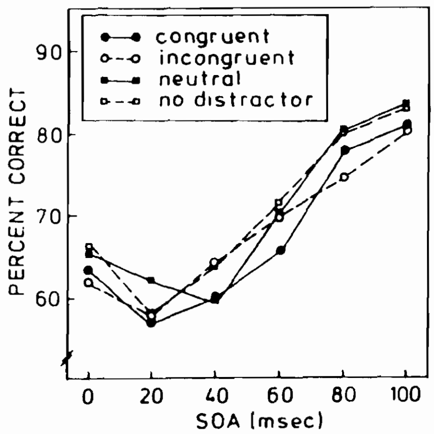

Figure 2. Percent correct forced-choice responses in a task in which subjects had to decide whether a masked arrow pointed to the left or to the right. The mask was a pattern that contained both kinds of arrows. The distractor was either a left-pointing or a right-pointing arrow (congruent or incongruent, with the direction of the target arrow) or neutral stimulus (a disk). Also shown are data from a no-distractor control condition. Data from 7 subjects averaged.

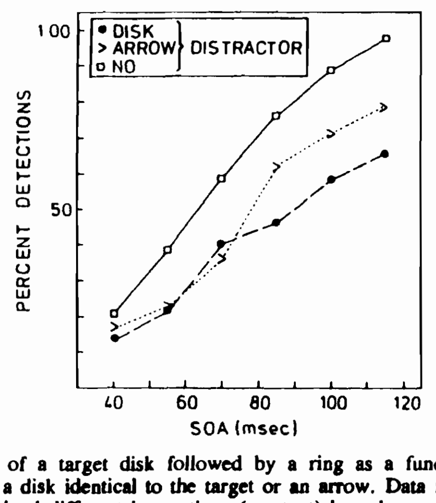

Figure 3. Detection of a target disk followed by a ring as a function of SOA. The distractor was either a disk identical to the target or an arrow. Data from two groups of 20 subjects who received different instructions (see text) have been combined since they did not differ statistically.

References

Adler, A. (1979). *Die Wirkung eines zusätzlichen Reizes im Gesichtsfeld auf den Verlauf der Metakontrast-Funktion: III. Ein Kontrollexperiment mit objektiven Leistungsmaßen.* Unpublished Thesis, Ruhr-Universität Bochum.

Alpern, M. (1953). Metacontrast. *Journal of the Optical Society of America, 43,* 648–657.

Aufschläger, M. (1979). *Die Wirkung eines zusätzlichen Reizes im Gesichtsfeld auf den Verlauf der Metakontrast-Funktion: Aufblitzen und Erlöschen als Zusatzreize.* Unpublished Thesis, Ruhr-Universität Bochum.

Averbach, E., & Coriell, S. (1961). Short-term memory in vision. *Bell System Technical Journal, 40,* 309–328.

Breitmeyer, B.G. (1984). *Visual masking: An integrative approach.* New York & Oxford: Oxford University Press.

Bridgeman, B., Kirch, M., & Sperling, A. (1981). Segregation of cognitive and motor aspects of visual function using induced motion. *Perception & Psychophysics, 29,* 336–342.

Cazin, H. (1981). *Die Wirkung eines maskierten visuellen Reizes auf die zeitliche Verarbeitung des Maskierreizes: Psychophysische Messung.* Unpublished Thesis, Ruhr-Universität Bochum.

Cheesman, J., & Merikle, P.M. (1985). Word recognition and consciousness. In D. Besner, T. Waller, & G. McKinnon (Eds.), *Reading research: Advances in theory and practice,* Vol. 5. New York: Academic Press.

Dixon, N.F. (1971). *Subliminal perception: The nature of a controversy.* London: McGraw-Hill.

Dixon, N.F. (1981). *Preconscious processing.* Chichester: Wiley.

Eriksen, Ch.W. (1960). Discrimination and learning without awareness: A methodological survey and evaluation. *Psychological Review, 67,* 279–300.

Exner, S. (1868). Über die zu einer Gesichtswahrnehmung nöthige Zeit. *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften zu Wien, Mathematisch-naturwissenschaftliche Classe, 58(2),* 601–632.

Fechner, G.Th. (1860). *Elemente der Psychophysik.* Leipzig: Breitkopf & Härtel. (Reprint: 1964. Amsterdam: Bonset).

Fehrer, E., & Raab, E. (1962). Reaction time to stimuli masked by metacontrast. *Journal of Experimental Psychology, 63,* 143–147.

Fry, G. (1934). Depression of the activity aroused by a flash of light by applying a second flash immediately afterwards to adjacent areas of the retina. *American Journal of Physiology, 108,* 701–707.

Haber, R.N., & Standing, L. (1968). Clarity and recognition of masked and degraded stimuli. *Psychonomic Science, 13,* 83–84.

Holender, D. (1986). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *The Behavioral and Brain Sciences, 9,* 1–66.

Kraus, K. (1900). Universitätsbummel. *Die Fackel, 1(31),* 12–19.

Kraus, K. (1901). Universitäts-Bummel. *Die Fackel, 3(89),* 17–19.

Kraus, K. (1903). Die Fakultät in Liquidation. *Die Fackel, 5(144),* 3–8.

Kraus, K. (1907). Medizinisches Familienidyll. *Die Fackel, 9(223/224),* 3–5.

Liss, Ph. (1968). Does backward masking by visual noise stop stimulus processing? *Perception & Psychophysics, 4,* 328–330.

Marcel, A.J. (1983). Conscious and unconscious perception: An approach to the relation between phenomenal experience and perceptual processes. *Cognitive Psychology, 15,* 238–300.

McLeod, P., McLaughlin, C., & Nimmo-Smith, I. (1985). Information encapsulation and automaticity: Evidence from the visual control of finely timed actions. In M.I. Posner & O.S. Marin (Eds.), *Attention and Performance XI*. Hillsdale, N.J.: Lawrence Erlbaum.

Milewski, R. (1980). *Untersuchung der Metakontrast-Funktion mit einem Zwangswahl-Konturidentifikationsverfahren*. Unpublished Thesis, Ruhr-Universität Bochum.

Neumann, O. (1979). Visuelle Aufmerksamkeit und der Mechanismus des Metakonstrasts. In E. Eckensberger (Ed.), *Bericht über den 31. Kongreß der Deutschen Gesellschaft für Psychologie*. Göttingen: Hogrefe.

Neumann, O. (1982). *Experimente zum Fehrer-Raab-Effekt und das "Wetterwart"-Modell der visuellen Maskierung* (Report No. 24/1982). Bochum: Ruhr-Universität, Psychologisches Institut, Arbeitseinheit Kognitionspsychologie.

Neumann, O. (1989). Kognitive Vermittlung und direkte Parameterspezifikation. Zum Problem mentaler Repräsentation in der Wahrnehmung. *Sprache und Kognition, 8*, 32–49.

Neumann, O., & Müsseler, J. (1990). Visuelles Fokussieren: Das Wetterwart-Modell und einige seiner Anwendungen. In C. Meinecke & L. Kehrer (Eds.), *Bielefelder Beiträge zur Kognitionspsychologie*. Göttingen: Hogrefe.

Piéron, H. (1914). Recherches sur les lois de variation des temps de latence sensorielles en fonction des intensités excitatrices. *Année Psychologique, 20*, 17–96.

Reeves, A. (1982). Metacontrast: U-shaped functions derive from two monotonic processes. *Perception, 11*, 415–426.

Rosengärtner, B. (1980). *Die Wirkung eines maskierten visuellen Reizes auf die zeitliche Verarbeitung des Maskierreizes: Reaktionszeitmessung*. Unpublished Thesis, Ruhr-Universität Bochum.

Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs, 74* (Whole No. 498).

Stigler, R. (1910). Chronophotische Untersuchungen über den Umgebungskontrast. *Pflüger's Archiv für die gesamte Physiologie, 134*, 365–435.

Werner, H. (1935). Studies on contour: I. Qualitative analysis. *American Journal of Psychology, 47*, 40–64.