

**BODY PERCEPTION
AND CONSCIOUSNESS
CONTRIBUTIONS OF
INTEROCEPTION RESEARCH ¹**

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F O R S C H U N G S B E R I C H T E

AUS DEM

OTTO - SELZ - INSTITUT

FÜR

PSYCHOLOGIE UND ERZIEHUNGSWISSENSCHAFT

DER

UNIVERSITÄT MANNHEIM (WH)

**BODY PERCEPTION
AND CONSCIOUSNESS
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***Dedicated to György Ádám
on occasion of his 75th birthday***

Forschungsberichte aus dem Otto-Selz-Institut Nr. 38

Forschungsberichte aus dem Otto-Selz-Institut für Psychologie und Erziehungswissenschaft der Universität Mannheim

Herausgegeben vom geschäftsführenden Direktor des Otto-Selz-Instituts

ISSN 0931-1394

Wer will was *Lebendig's* erkennen und beschreiben,
Sucht erst den *Geist* heraus zu treiben,
Dann hat er die *Teile* in seiner Hand,
Fehlt leider nur das *geistige Band*.²
J. W. VON GOETHE [1]

1. Introduction

In looking back at the last three decades of interoception research in the Department of Comparative Physiology at Eötvös Loránd University Budapest from the standpoint of an external cooperating group it seems appropriate to consider its impact on recent and future developments in the field and related areas of psychobiology. We will do this by concentrating on a series of experiments inspired by our cooperation with G. Ádám's group since 1985 [2-5]. Their results have important bearings on a current issue in the consciousness debate.

1.1. Visceroception and Somatosensation

The issue in question is on the role of body perception in general and perception of visceral events in particular in the constitution of a conscious self through the construction of the so-called "**body self**". This term has become fashionable again since Damasio's bestselling book on "**Descartes' Error**" [6] and refers to the **embodied "Me"** as the integrative centre around which **perceptions** and **orientation in space**, **feelings** and **thoughts**, **plans** and **volitional acts** are organized by the brain.

Damasio's model of "**somatic markers**" particularly emphasizes the contribution of **visceral feedback** in affect and action control, that is, from our **inner organs**, the heart and the guts, in addition to tactile signals from the skin and proprioceptive signals from muscles, joints and the labyrinth.

The model implies a crucial role of central body representation in the constitution of a conscious self, but **its dynamics**, the ways in which somatosensory and viscerosensitive afferent flows become integrated into the experience of the embodied self, have remained in the dark. In this respect, we seem to know

not much more than the early researchers on the “body schema” like Horowitz, Schilder, Penfield or Luria, to name a few [7-11].

1.2. The Role of Awareness

In particular, we do not know at which level of **awareness** the information from somatic and visceral afferents is processed and combined to exert their alleged control on affect, intention, and action. This seems strange as there is a **long tradition of research** on somatosensation on the one side and on visceroreception on the other, the latter being connected much with the Department of Comparative Physiology.

But it is as if we had only the pieces in our hands and would be lacking in the “**geistige Band**”, the conceptual bond, to which Johann Wolfgang referred in the motto above. The situation might change considerably when those two traditions could be combined.

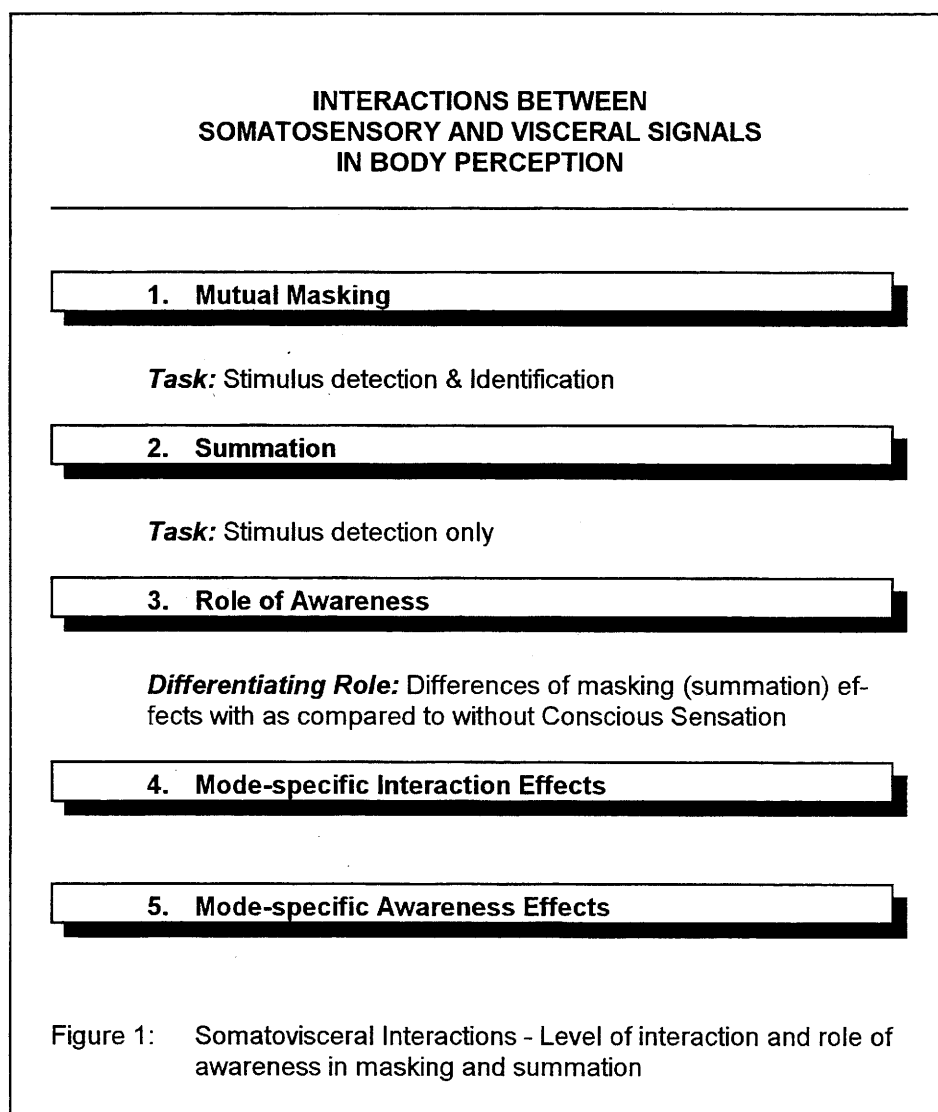
Beginning with Ádám’s classic on “**Interoception and Behavior**” 30 years ago [12], psychophysiological knowledge has accumulated showing that interoceptive information may control behavior requiring highest brain levels such as discriminative learning without necessarily reaching awareness by the subject.

But little is known about the **differences in processing** with - as compared to without - awareness. Not much is known either about these differences in somatosensation, and almost nothing is known about **mutual influences between the two sensory channels** at different levels of awareness over and above the older physiological and clinical work on referred pain etc. since Head and others [13-14].

Knowledge on such **somatovisceral interactions** at the perceptual level would be basic, however, to a better understanding of those integrative mechanisms at the highest level of the body schema, the **body image**, to which Damasio was referring to.

1.3. Somatovisceral interactions

Before my colleagues and I started out on this question only one other psychophysiological study had appeared in 1990 dealing with somatovisceral interactions in visceral perception of humans, and, as you might have guessed, it stemmed from Ádám's group [15]. It investigated the **masking** (No. 1 in Figure 1) of a visceral distension stimulus by an abdominal stimulus in a special preparation with colostomy patients by way of a so-called signal detection approach. But it did not directly address the relation between **awareness** and somatovisceral masking (No. 3 & 5).



The question of **awareness-specific effects in interoception** was what we have been primarily interested in since we started out on interoception about 10 years ago with a series of studies on the **psychophysics** of intestinal mechanoreception, on the **discriminability** between internal and external, abdominal stimuli, and on their **interactions** below and above conscious sensation.

In the following I will shortly describe two experiments of this series, one taking up Ádám's lead on somatovisceral masking, the other on its counterpart, summation, about which no study had been done so far.

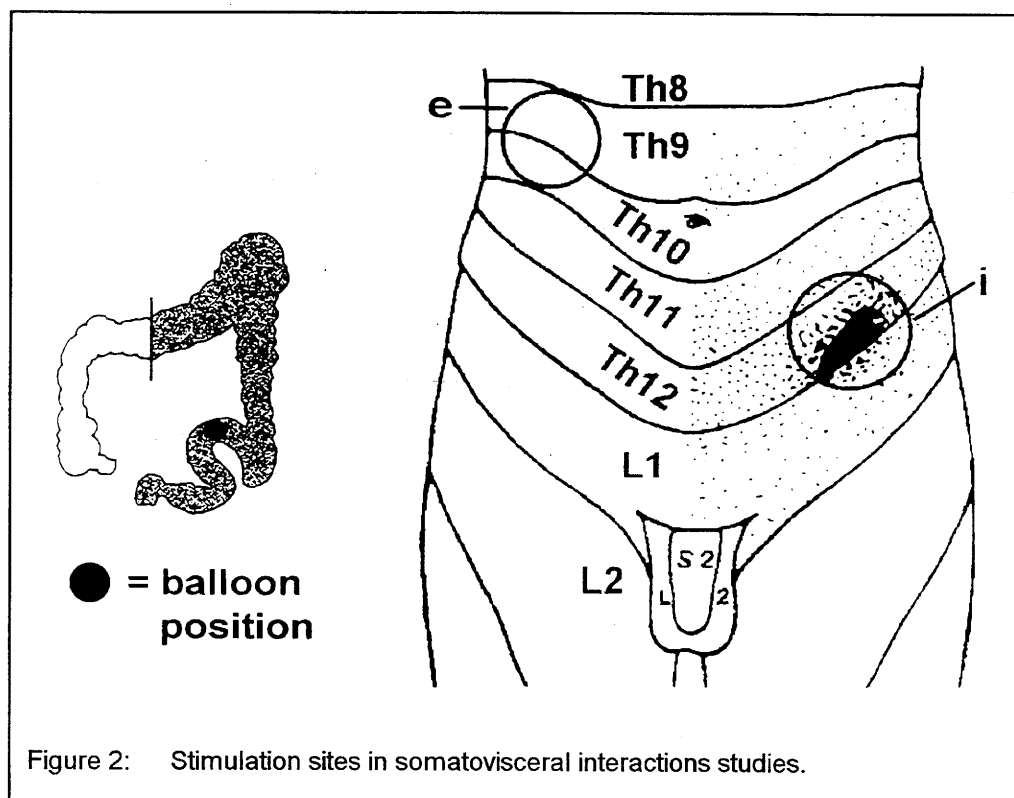


Figure 2: Stimulation sites in somatovisceral interactions studies.

2. Somatovisceral Masking

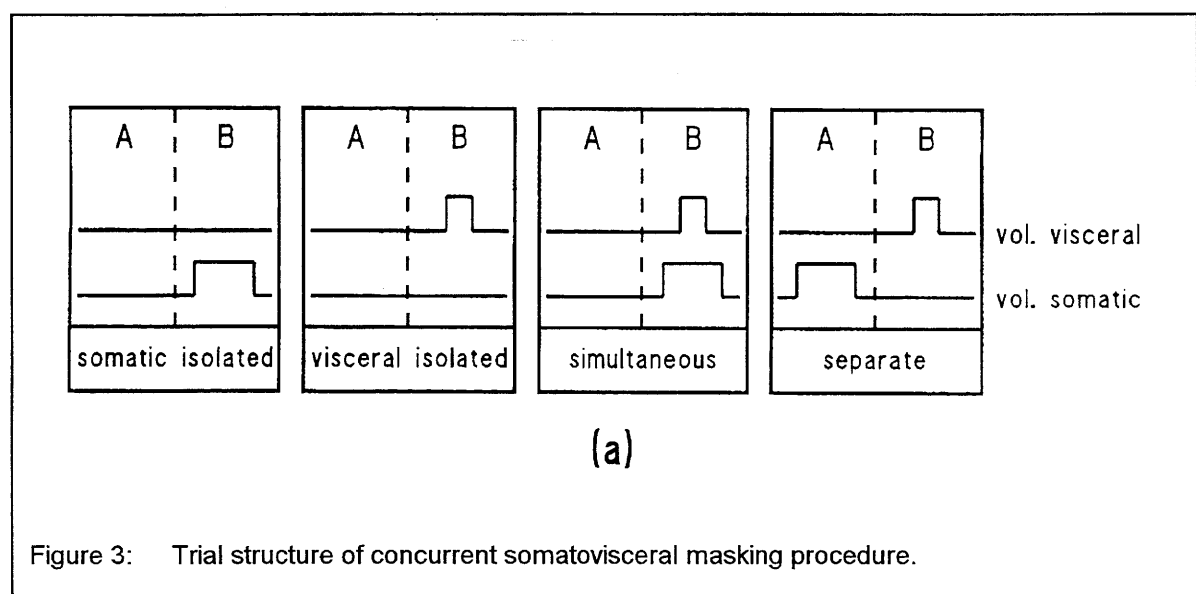
Figure 2 illustrates the stimulation sites which we used for the somatovisceral interaction studies: The visceral stimulus was applied by a balloon probe in the sigmoid colon, the external abdominal stimuli by a ring-shaped stimulator as in Ádám's study at two abdominal sites (Figure 2: marks i & e), one within, the other outside the abdominal reference zone from which visceral and so-

matic afferents converge at the spinal level according to neurophysiological studies [16].

The psychophysical method differed from Ádám's in two important respects:

(1) **A continuous tracking method** called **multiple staircase** was used to assess interoceptive and somatosensory thresholds concurrently within the same subject. This controls for instationarities of perceptual thresholds over prolonged periods of testing and for interindividual variance. The method is a somewhat sophisticated version of the famous **Békésy-Method** of continuous auditory threshold estimation in which the intensity of the stimulus is tracked up or down depending on subject's discrimination response, except that a multiple of thresholds is tracked in parallel.

(2) **A forced-choice paradigm** with two observation intervals A and B (Figure 3) was applied in which the subject is forced to decide in which interval the stimulus had occurred even when he has not felt anything.

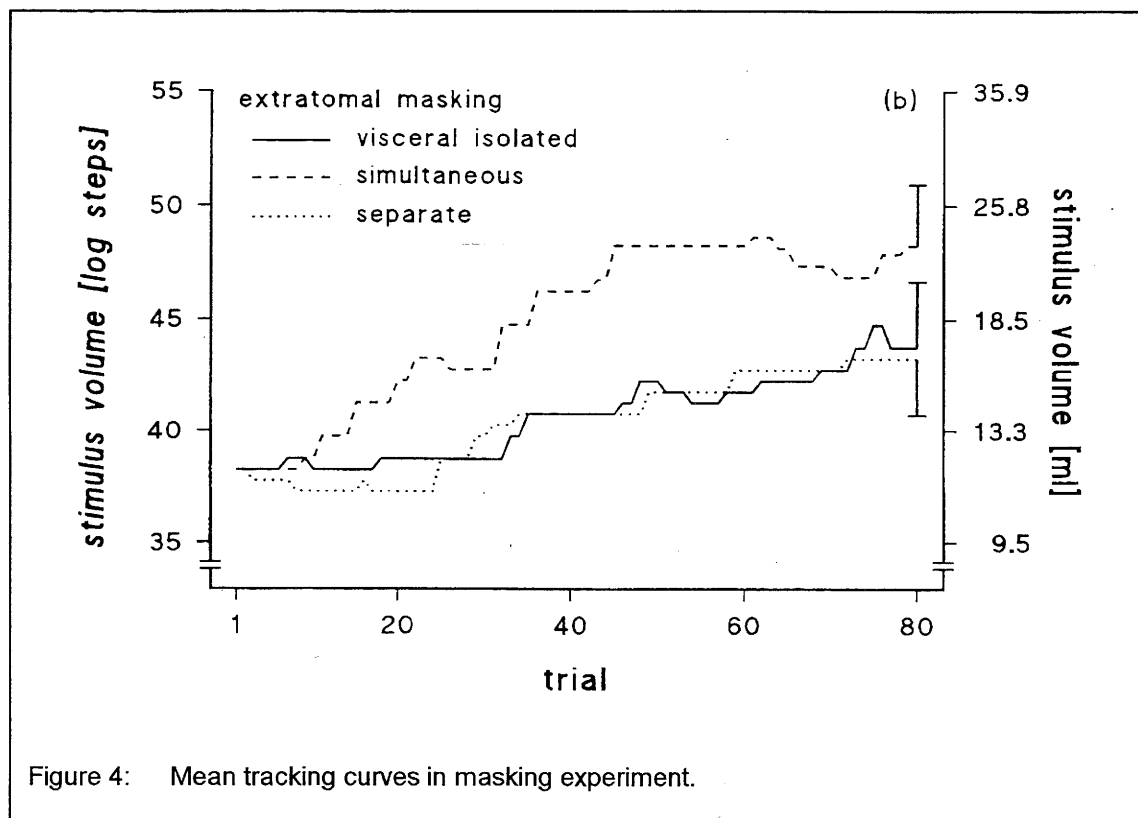


In addition, a subjective rating of the intensity felt, ranging from “not felt” to “strongly felt”, was requested at the end of the trial. This allowed concurrent testing of discrimination with or without conscious sensation - and the sensation itself which all were to be compared.

In the case of somatovisceral masking illustrated in Figure 3, four kinds of stimuli or stimulus combinations are presented and their corresponding discrimination thresholds were continuously assessed by the multiple staircase:

- a) **Visceral** distension **“isolated”** (first frame in Figure 3),
- b) **abdominal** pressure **“isolated”** (second frame in Figure 3),
- c) visceral and abdominal stimulus **overlapping** (third frame in Figure 3), and
- d) visceral and abdominal stimulus **combined**, but in **separate** observation intervals as control (last frame in Figure 3).

The subject is asked in which of the observation intervals the visceral and the abdominal stimulus occurred. The intensity is adjusted in the next trial depending on hit or miss of the subject for the particular stimulus.



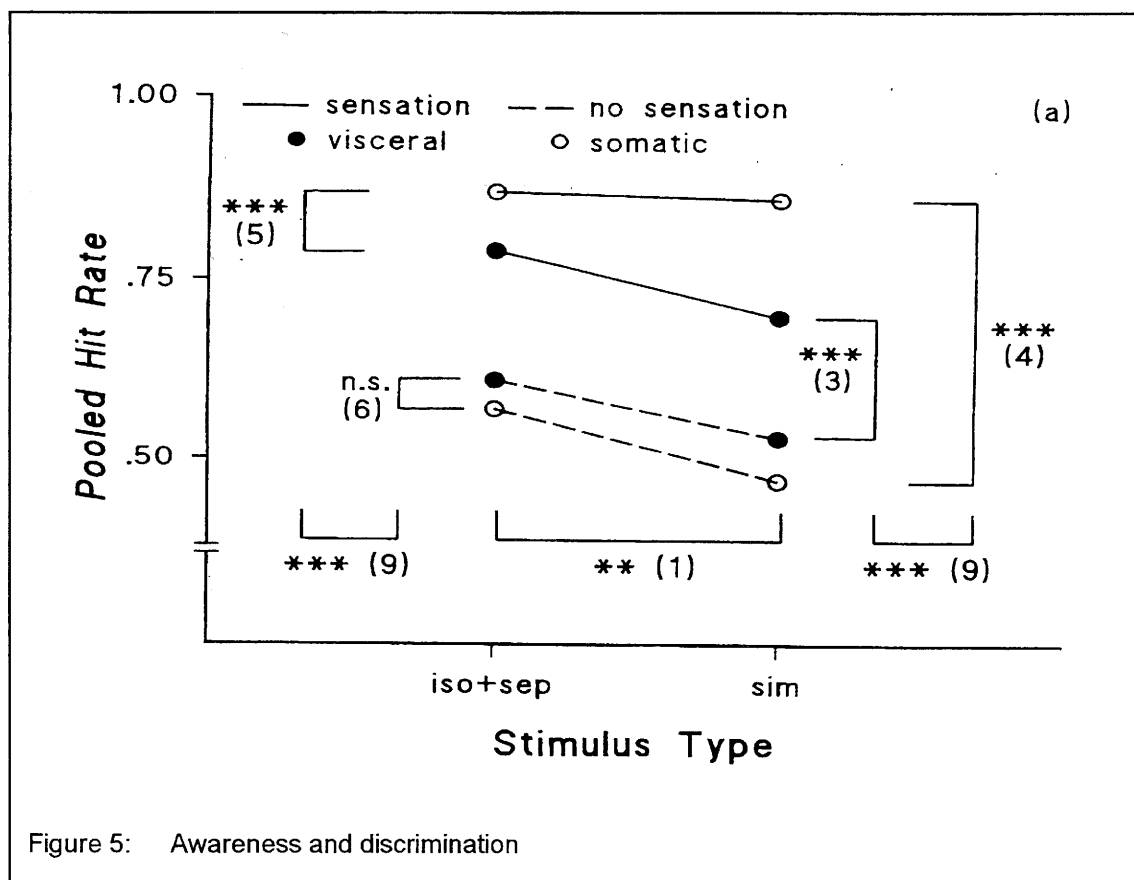
As one can see from the group trackings in Figure 4, combining visceral and somatic stimulus resulted in **distinct elevation of visceral thresholds** shown by the upper curve in the case of overlapping combination, but not in the separate combination which gave the same thresholds as when the visceral stim-

ulus was presented alone. This demonstrates **somatosensory masking of the visceral stimulus**.

There are two interesting aspects in the results of this study which differ from other masking experiments in exteroception:

Firstly, the masking relation is asymmetric, that is, the abdominal stimulus is not masked by the visceral stimulus.

Secondly, the masking effect on the visceral stimulus is not greater when the abdominal stimulus is presented within the spinal reference zone as compared to outside. This shows that the effect is not produced by somatovisceral convergence neurons at the spinal level but supraspinally, presumably in the somatosensory cortex, S(II).



Thirdly, and most important, there are **specific differences** in visceral and somatosensory discrimination performance when the subject had also had a conscious sensation as to compared when he had not:

This is shown in Figure 5 which may look a bit complicated at first, although its message is rather simple, that is, there is a qualitative difference between visceroreception and somatosensation under different awareness conditions:

- Hit rates in trials in which the subject had a conscious sensation were higher than those in trials where no sensation occurred - as one would expect.
- But, in addition, the difference between hit rates under the two awareness conditions is much greater for the abdominal, that is, the somatic stimulus as compared to the difference for the visceral stimulus.

As it seems, the visceral discrimination is **less strongly coupled to conscious sensation** than is the tactile discrimination on the abdomen!

- And finally, the difference is accentuated by the effective masking of the visceral stimulus by the somatosensory abdominal stimulus: Hit rates of the visceral discrimination are higher in the presence of a conscious sensation when presented separately, but do not drop to chance level under masking ($= .50$). In contrast, they do for discriminations without sensation. Again, this is different from somatosensation.

Analogous specifics appear when sensation rate is considered as a function of hits or misses of the forced choice discrimination which is illustrated in Figure 6.

The details would lead to far here. It will be sufficient for the present purpose to note that there are not only characteristic somatic-visceral differences in masking as such but also in the masking effect on the relation between forced stimulus detection and conscious sensation of the stimulus.

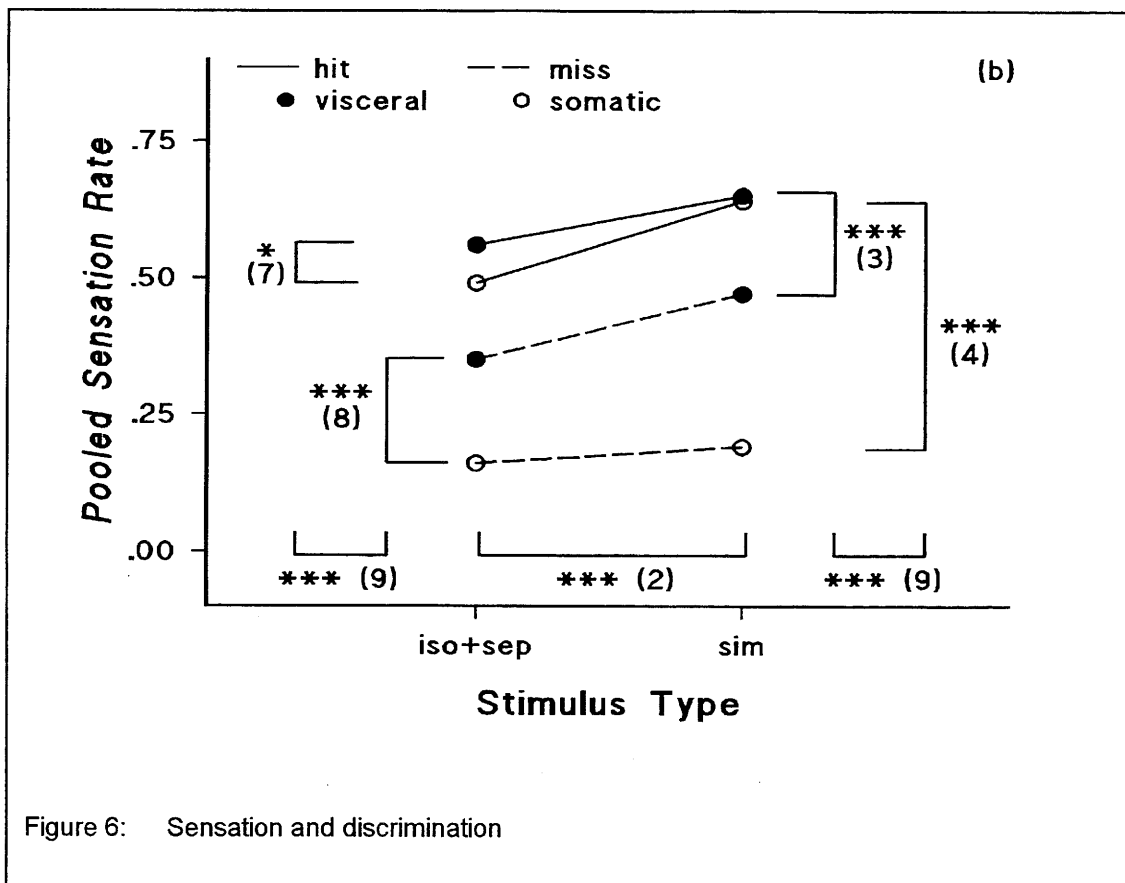


Figure 6: Sensation and discrimination

3. Somatovisceral Summation

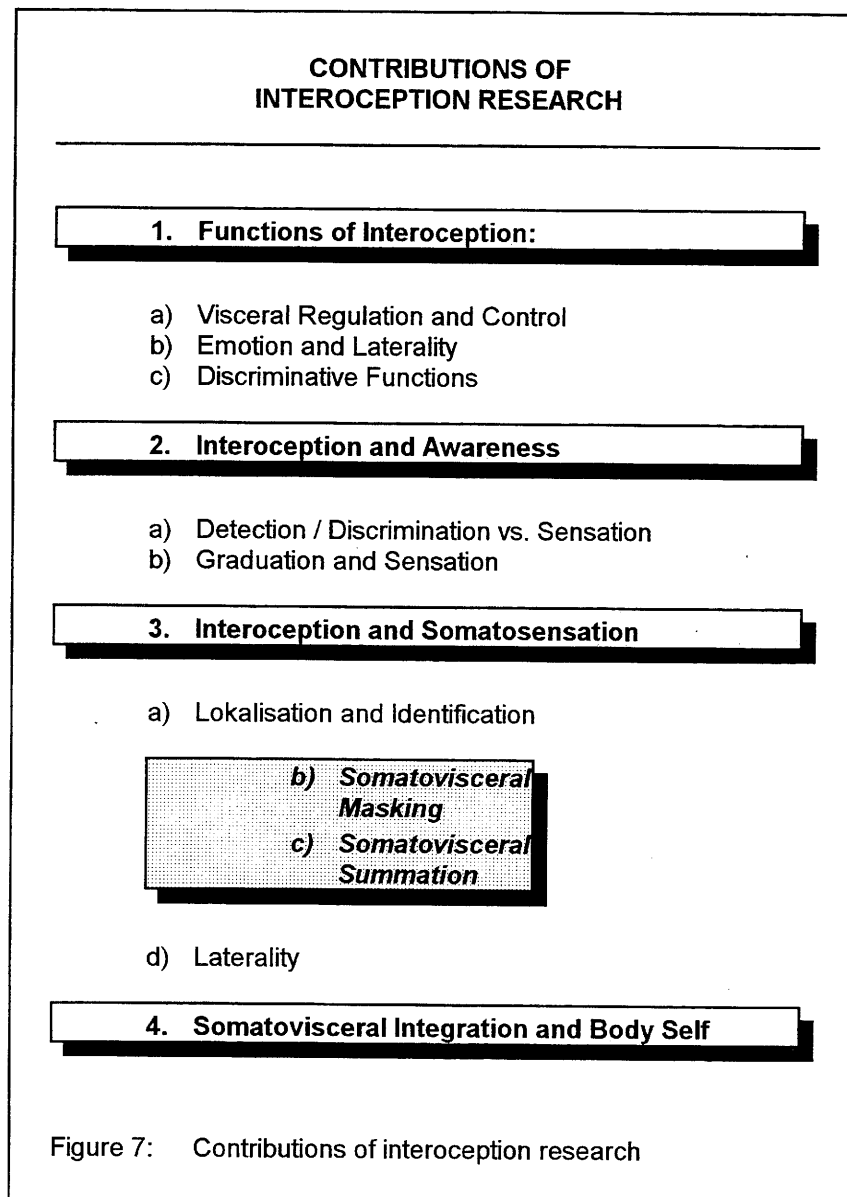
Because lack of space we will not describe the second experiment on somatovisceral summation in any detail but would like to add just this much:

In the summation task the subject is not to identify the sensory mode or channel (visceral or somatic) as in the masking condition but he has only to detect any stimulus at all. In this case, internal and external signals may be combined to increase detection rate when presented in combination.

This is in fact the case and thresholds drop while hit rates go up. The interesting thing is, that in this condition ***no decoupling of sensation and discrimination*** takes place and ***visceral and somatic discrimination do not differ*** in this respect.

4. Conclusion

As one can (or should) see from the examples, ***mode-specific effects of awareness*** may be found when taking a closer look at visceroreception and somatosensation and their relations.



And, in addition, this may ***vary with the kind of information*** the subject has to extract from the dual sensory inflow from the body to solve a given task, for instance, ***discriminating between*** sensory modes or ***using both*** in conjunction.

This is the kind of perceptual dynamics that we would like to know if we were ***to build a model*** of how and at what cognitive level visceral signals become integrated with somatosensory inflow - and if talk of “body self” and “somatic markers” is to become ***more than a façon de parler***.

It is our conviction that such a model would have to make systematic use of old and new contributions of interoception research to the problem of central body representation as summarized in Figure 7.

And it is our hope that this might finally provide us with the ***“geistige Band”*** we have referred to in the beginning - although we, too, presented only ***pieces in our hands***.



Acknowledgement

The research in the Laboratory of Clinical Psychophysiology at the University of Mannheim and the collaboration with Dr. Ádám's group in Budapest was generously supported by the Deutsche Forschungsgemeinschaft, DFG, by continuing grants to the first author since 1985 (Ho 904/3 through 8). Without this support neither the particular experiments nor the inspiring cooperation with the Human Psychophysiology Group of the Hungarian Academy of Sciences would have been possible. The DFG also supported several research visits of our group in Budapest and a visit of Dr. Ádám in Mannheim jointly with the Hungarian Academy of Sciences.

Notes

1. This report is based on an invited paper read by the first author before the Hungarian Academy of Sciences at the 30th Anniversary Symposium of the Department of Comparative Physiology, Eötvös Loránd University, and the Human Psychophysiology Group of the Hungarian Academy of Sciences, Budapest, 18th December 1997.
2. English translation (R.H.): "Who would know and describe a living thing / Tries first to drive its spirit out, / Then with the pieces in his hand, / He lacks their spiritual bond." [1]

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