LATERALITY, EMOTION, AND BILATERAL ELECTRODERMAL ACTIVITY:
VERBALIZATION REDUCES SKIN CONDUCTANCE RESPONSES AFTER RIGHT HEMISPHERIC EMOTIONAL STIMULATION

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In several studies we tested the hypothesis of a right hemispheric superiority in emotional processing with recordings of peripheral-physiological activity. Using a visual half field paradigm, emotionally charged and 'neutral' stimuli (slides of patients with dermatological diseases before and after cosmetic surgery) were selectively presented to both hemispheres while measuring phasic bilateral electrodermal activity. The authors' previous studies had revealed contradictory results: Differential hemispheric effects supporting theories of a right hemispheric advantage in emotional processing which emerged in one study could not be replicated in a follow-up design (summarized in Kayser & Erdmann, 1992). Since procedural effects causing increased verbalization of Ss had been suggested as a post hoc explanation, the present experiment tested explicitly the influence of a verbal strategy, i.e., Ss were instructed to label each stimulus. In contrast to an imagery instruction, verbalization resulted in lower electrodermal reactivity, particularly for the negative slides. Furthermore, while no hemispheric differences were observed for the neutral stimuli under the verbalization condition, left hemispheric emotional stimulation led to larger and more frequent SCRs compared to left hemispheric neutral stimulation, and right hemispheric emotional stimulation revealed the inverse pattern. Besides these strategy effects, trait anxiety proved to interact in a complex manner with the experimental factors, emphasizing the importance of individual differences for electrodermal phenomena.

Concerning possible asymmetrical cortical influences on bilateral electrodermal activity (excitatory vs. inhibitory and ipsilateral vs. contralateral) the results match our former findings favoring a contralateral excitatory or ipsilateral inhibitory cortical control.

A precise question represents the starting point of the present paper:

Does the activation of verbal resources and therefore of left hemispheric processes influence the processing of emotional relevant stimuli and, if so, how does this influence affect autonomic variables which normally correspond to emotional stimulation?

We derived this question from several investigations in which we tested the hypothesis of a right hemispheric advantage in emotional processing from measures of peripheral-physiological activity, which had led to conflicting results (summarized in Kayser & Erdmann, 1992).

A bulk of evidence suggests a functional hemispheric specialization of emotional processes, e.g., studies recording lateralized expressive behaviour or emotional states, respectively, and experiments with lateralized stimulus exposures in unilateral lesioned patients (e.g., Gainotti, 1989) as well as in healthy subjects (e.g., Silberman & Weingartner, 1986). Right-hemispheric superiority is mainly supported by evidence regarding the perception of emotional stimuli, particularly with negative valence (e.g., Etcoff, 1989). However, both hemispheres seem to contribute to emotional
experience, but the relationship between specific patterns of cortical activity and specific emotional states is as yet unclear (Leventhal & Tomarken, 1986).

After inactivation of the right but not the left hemisphere, patients with unilateral lesions and Wada-test patients demonstrate reduced vegetative reactions especially to emotional stimuli, e.g., for cardiovascular and electrodermal parameters (reviewed by Gainotti, 1987; Heilman, Schwartz & Watson, 1978; Morrow, Vrtunski, Kim & Boller, 1981; Zoccolotti, Scabini & Violani, 1982; Yokoyama, Jennings, Ackles, Hood & Boller, 1987; Caltagirone, Zoccolotti, Originale, Daniele & Mammucari, 1989; Zamrini, Meador, Loring, Nichols, Lee, Figueroa & Thompson, 1990). But peripheral-physiological indicators of emotion have rarely been recorded in healthy subjects while studying hemispheric asymmetries with lateralized stimulus presentations, although electrodermal measures are generally supposed to be sensitive to emotional stimulation (Hugdahl, 1984, 1988).

Thus, all our experiments are based on the basic plan sketched in Fig. 1, a three-factorial, entirely repeated measure design. Hemispheres were selectively stimulated by tachistoscopic exposures of charging or neutral stimuli in the right (LH) and left (RH) visual field, respectively. The stimuli consisted of slides from patients suffering from dermatological diseases, one half displaying disordered facial areas before or immediately after surgical treatment, the other half showing the same facial areas a few years after the operation, i.e., healthy skin or a healed scar. Hence, slides after the operation act as relative good direct controls which differ essentially from the ‘negative’ stimuli only in the emotionally relevant aspect. At the same time, bilateral phasic electrodermal responses were measured in order to take a possible asymmetrical influence on autonomic variables into account (to this issue cf. Freixa I Baqué, Catteau, Miossec & Roy, 1984; Hugdahl, 1984; Miossec, Catteau, Freixa I Baqué & Roy, 1985). Only female right-handed subjects were investigated.

All slides were exposed once to each visual field, exposure time was 1000 ms. Horizontal eye movements were continuously recorded by EOG. Where the eye movement was more than two

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<th>hemisphere</th>
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<td>stimulus quality</td>
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<td>response hand</td>
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**Fig. 1.** Basic design.
degrees from fixation then this trial, the exposure of this particular stimulus to the other visual field and the respective trials for the reference stimulus were all discarded. Subjects who scored on less than 50% of valid trials were rejected from analysis (for further details see Kayser & Erdmann, 1992).

A first study using these stimuli revealed for each of two indicators a meaningful interaction hemisphere x stimulus quality. As shown in Fig. 2, for the response intensity, obtained as magnitude measures by calculating the square root of the largest response within a time frame of 1 to 5 s after the onset of the stimulus exposure, there were larger responses on average after right hemispheric stimulation to ’emotional’ than to ’neutral’ stimuli whereas after left hemispheric stimulation differences were smaller and in the opposite direction. The same effect was observed for the frequency of responses, i.e., whether a specific SCR occurred within the time window or not, which showed more reactions on average for ’negative’ than for ’neutral’ slides after right hemispheric stimulation, but none or reversely directed differences after left hemispheric exposures.

![Fig. 2. Study I: Interaction stimulus quality x hemisphere for parameters of response frequency and response intensity.](image)

However, we failed in an attempt to replicate these results, as can be seen from the results of a second study carried out under similar conditions which rather revealed the opposite effect (cf. Fig. 3). In contrast to study I, only the main effect for the stimulus material proved to be significant, i.e., more and larger responses for negative stimuli.
In order to explain these inconsistent results we have formulated the post hoc hypothesis that in study II slightly different task requirements led to a strengthened activation of left hemispheric verbal resources. In both studies subjects were asked to judge their experience after each stimulus presentation but in study II a global stimulus classification was also demanded. It seemed likely that this supplementary verbal demand favored the left hemisphere in particular, since the clearest differences between study I and II were observed for the left hemisphere while the pattern for the right hemisphere remains relatively similar.

In this context it is significant that a few authors (e.g., Tucker, 1981; Fox & Davidson, 1984) have postulated that the left hemisphere may dampen a negative arousal which is caused by a right hemispheric frontal activation via interhemispheric inhibitory mechanisms. An inhibitory influence of the left hemisphere is supported, for example, by a study by Tucker & Newman (1981) in which verbal and analytic strategies were particularly effective at inhibiting an emotional arousal.

Thus, we have tried to test our post hoc hypothesis explicitly in another study by instructing one group (n=16) to verbalize each stimulus internally, a second group (n=16) was advised to conceive each stimulus as one’s own mirror image (cf. Fig. 4). The verbal instruction condition should induce a verbal and therefore a left hemispheric strategy while the mirror image instruction should provoke

![Fig. 3. Study II: Interaction stimulus quality x hemisphere for parameters of response frequency and response intensity.](image)
an imagery and thus a right hemispheric strategy.

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**Fig. 4.** Extended design of study III with between-subject factors *instruction* (verbal vs. imagery) and *trait anxiety* (HA: high trait anxiety vs. LA: low trait anxiety).

In addition, subjects’ *trait anxiety* was considered as a quasi-experimental factor. Tucker & Williamson (1984) have proposed a model which claims *anxiety* to be associated with a left-lateralized activation system. This linkage is supported by the finding that high trait- and state-anxious individuals are characterized by an analytic perceptual style, presumably reflecting heightened left-hemisphere activity (Tucker, Antes, Stenslie & Barnhardt, 1978; Tyler & Tucker, 1982). Because *anxiety* as a personality trait may also influence the results systematically in the sense of a moderator variable both experimental groups were divided into high and low trait-anxious subjects. This assignment was carried out by combining the scale medians of the neuroticism and extroversion values which had been determined with the German version of the *Eysenck Personality Questionnaire* (EPQ-R) (Ruch & Hehl, 1989).

As shown by Fig. 5, the *verbalization* instruction did reveal an inhibition of emotional arousal, particularly for stimuli of negative valence, while the *imagery* instruction exposed the expected main effect for the stimulus material, i.e., larger and more specific SCRs. The respective interaction *instruction x hemisphere* proved to be significant for the amplitude parameter and marginally significant for the parameter of response frequency.
The interaction stimulus quality x hemisphere missed the statistical level of significance for the verbalization instruction (cf. Fig. 6). But considering trait anxiety as a factor a marginal significant three-way interaction stimulus quality x hemisphere x anxiety emerges for the verbal instruction. As it is shown in Fig. 7 for the parameter response frequency, a verbal instruction reduces reactivity after right-hemispheric ‘emotional’ stimulation only for the low-anxiety subjects while for the high-anxiety subjects response level is generally low and does not discriminate at all. If a verbal instruction really did induce a left-hemisphere strategy, and trait anxiety were per se associated with a heightened left-hemispheric activation, ergo we could expect an experimental effect of the verbal instruction to appear prevalently with low-anxiety subjects, as is the case here: A left hemispheric strategy affects asymmetrically autonomic responses which were provoked by stimulation with emotional charging stimuli. The tendency of the results is in accordance with the hypothesis of Tucker (1981), that the right-hemispheric arousal mechanisms are subjected to an inhibitory control of the left hemisphere. That is, in contrast to our initial hypothesis the left hemisphere does not seem to profit from a left-hemispheric strategy but the right hemisphere is at a disadvantage.
Fig. 6. Study III: Mean values for factor levels of *stimulus quality* x *hemisphere* for *verbal* instruction for parameters of response frequency and response intensity.

Fig. 7. Study III: Interaction *stimulus quality* x *hemisphere* for *verbal* instruction for response frequency, plotted separately for low and high *trait anxiety*.

Regarding the effects for the other strategy group (cf. Fig. 8) it becomes evident that the right hemisphere does not profit from our second instruction condition but rather the left hemisphere does:
There were more and larger responses to emotional stimuli only after left hemispheric exposures. But it is difficult to interpret this result since it seems from a post questionnaire that we have been less successful in realizing an imagery strategy.

Fig. 8. Study III: Interaction stimulus quality x hemisphere for imagery instruction for parameters of response frequency and response intensity.

Fig. 9. Study III: Interaction stimulus quality x hemisphere for verbal instruction for response frequency, plotted separately for low and high trait anxiety.
As can be seen from Fig. 9, the mirror image strategy has been used less frequently in the imagery condition than a verbal strategy in the verbalization condition. Furthermore, in the mirror image condition subjects possibly partly verbalized spontaneously, at least more often than they used a different strategy, consequently it is questionable whether this instruction induced really primarily an imagery and therefore a right hemispheric strategy.

Regarding the question of an asymmetrical cortical influence of the innervation of the sweat glands (i.e., ipsi- vs. contralateral and excitatory vs. inhibitory, respectively; e.g., Hugdahl, 1984), the present results match our former investigations, which revealed larger and more specific SCRs on the hand contralateral to the stimulated hemisphere, which supports a contralateral excitatory or an ipsilateral inhibitory cortical control. Fig. 10 shows the effects of both response hands for low-anxious subjects in the verbal instruction condition. The analysis of variance revealed firstly a main effect response hand with larger responses on the right hand (R>L) which has to be expected in the case of left-hemisphere activation (low anxiety and verbal instruction) and the assumption of a contralateral excitatory or an ipsilateral inhibitory influence. Secondly a two-way interaction hemisphere x response hand was found which shows the hand effect R>L to be smaller after right hemispheric stimulation, which also conforms with the hypothesis contralateral excitation or its counterpart ipsilateral inhibition respectively. And thirdly a three-way interaction stimulus quality x hemisphere x response hand proved to be significant which can be attributed to the fact that

![Fig. 10. Study III: Interaction stimulus quality x hemisphere x response hand for verbal instruction and low trait anxiety for response intensity, plotted separately for both hemispheres.](image)
significantly larger responses on the right hand failed to appear after right-hemisphere presentations of negative stimuli, i.e., the hand effect R>L fades with presumed activation of the right hemisphere with emotional charging stimuli. Again this gives support to the hypotheses of *contralateral facilitation* and *ipsilateral inhibition* respectively, and contradicts assumptions of a *contralateral inhibitory* or *ipsilateral excitatory* cortical influence on electrodermal activity.

In summary, the observed strategy effects agree with the forecasts, 1) as a verbal and analytical strategy reduces a peripheral-physiological arousal, and, 2) this reduction is subject to an asymmetrical cortical influence. This asymmetrical relation is in complete accordance with the study of Tucker & Newman (1981) mentioned before, and also in agreement with the concept of a left-hemisphere inhibitory control on right-hemispheric arousal mechanisms. This relation is possibly not valid for all individuals since *trait anxiety* influenced significantly the effects, suggesting the need to consider individual differences in these studies.

Once again, the induction of an imagery strategy has proven to be difficult, possibly because of an improper operationalization: *conceiving one’s mirror image* differs perhaps from *letting the stimuli sink in*, which could have been the better strategy variation.

But maybe we are also dealing in this connection with a theoretical issue, i.e., *experience vs. perception or recognition* of emotionally meaningful stimuli. For instance, reaction time to right-hemisphere exposure of visual stimuli is selectively delayed during negative affects but not during the generation of neutral imagery (Ladavas, Nicoletti, Umilta & Rizzolatti, 1984). Provided an imagery strategy resulted indeed in a frontal right hemispheric activation for stimuli of negative valence, and - as, for instance, repeatedly postulated by Tucker (1987, 1988; Tucker & Williamson, 1984) - this frontal activation inhibits reciprocally ipsilateral posterior areas (Tucker, Stenslie, Roth & Shearer, 1981), thereby interfering with right-hemisphere perceptual mechanisms which rely on temporal-parietal activation. For testing such hypotheses an independent indicator of cortical activity is required, i.e., a continuation of this approach should comprise parallel registration of peripheral-physiological and central nervous parameters. Such a procedure could certainly shed light upon the relation of an asymmetric cortical control on electrodermal phenomena which have been repeatedly noticed in our studies.
References


Plenum Press.


