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# Painful and non-painful stimuli range as a base of context effect

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In two separate experiments, the effect of stimulus context on ratings of perceived intensities induced by the electrocutaneous stimulation was investigated. The stimulus context was operationally defined as a range of stimuli used in one set of measurement (narrow-large). In the first experiment narrow stimuli range consisted of 5 electrocutaneous stimuli with intensities below the pain threshold. The large range, along with these 5 stimuli, included 5 more stimuli, painful in their intensity. The aim of this experiment was to investigate the ratings of stimulus intensity of those stimuli whose intensity was below the pain threshold in the narrow range series in comparison with these ratings in the series of both below and above the threshold level. The results show a significant difference of stimulus intensity assessments between two experimental conditions. In the condition with narrower range (when all the intensities are below pain threshold level) the intensity ratings are significantly higher then in the case of larger stimuli range. Second experiment tested the same context in relation to the ratings of the painful stimuli. A large stimuli range consisted of painful and non-painful stimuli, while narrow range consisted only of painful stimuli. This study showed no significant difference in the mean ratings level for painful stimuli regardless of the context of painful stimuli or the context of painful and non-painful stimuli.

Both studies showed significant interaction of stimuli context and stimuli intensity. The largest differences between large and narrow stimuli range were found with more intensive (not-painful) stimuli, while second study showed marked differences of the two stimuli range with the least painful stimuli. These results confirm the importance of the stimuli context in perceived intensity of electrocutaneous stimulation. Variations in intensity ratings are smallest among the least intensive and the most intensive stimuli while mainly the intensity ratings of the mid-intensity stimuli is influenced by the stimuli context.

A fundamental psychophysical question is whether sensation attributes can be estimated on an absolute level. Basically, it can be assessed, that it is not possible: Neither in controlled experimental condition, nor in the real-life, people are able to estimate various stimuli attributes on the basis of their absolute level. In other words, they do it on a certain relative level (Parducci, 1963). An example of the most simple experimental condition confirms this notion. The estimation of a tone's intensity depends on the intensity of the previously presented tone. So, intensity assessment of the second tone in the series, although objectively equally intense as the first tone presented, will tend to be perceived higher (e.g. Cross, 1973; Jesteadt, Luce & Green, 1977).

The estimation of stimulus intensity is often influenced by the presence of other contextual stimuli, and this fact poses two important questions: What are the underlying mechanisms of stimuli context effect and what kind of implications does the notion of context have for the validity of psychophysics measurements. Answering the first question, answers the second. As far as the underlying mechanisms of stimuli context is concerned, a primary question is on what level is this effect attainable.

Poulton (1979) tried to describe and explain the effect of stimuli context on the level of errors in the measurement, that is, more controlled experimental condition could avoid the subject tendency to give relative estimation. Stevens (1957), as well, gave no theoretical importance to the effect of stimuli context. Other factors that might influence the estimation of stimuli intensity can be considered noise and they should be eliminated from the descriptions of psychophysical laws. This notion emphasizes the role of contextual influence as subsidiary variable that should either be impelled from the experimental design or at least held under control.

New concepts of stimuli context effect have different assumptions of its role and importance. The presence of other stimuli (varying in range, frequency or intensity) has

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to be taken into account, not only on the methodological level, but also on a theoretical one, that is, the context needs to be treated as an error-provoking factor in subjects. Anderson (1975; 1992; 2001) was among the first to consider stimuli context as an important experimental variable. This theoretical frame emphasizes the possibility of stimuli context being an important variable in investigating the way our sensory system integrates different types of information present in the observation process and not just a nuisance that needs to be controlled or eliminated. *"Context effects are not a nuisance in the way of measurement but instead can provide a conceptual-methodological foundation for psychophysics" (Anderson, 1992, p. 98). "Indeed, contextual stimuli are an important special case of the axiom of stimulus integration" (Anderson, 2001, p. 181).*

Recent research shows that there is also an empirical basis of this theoretical concept. Marks conducted his fundamental research, that later served as a milestone, to test the basic ideas (Algom & Marks, 1990; Marks, 1992; Marks 1993, Marks & Warner, 1991). The basis of this research was the assumption that matching tones of different frequency by their intensity can largely depend on stimuli context. The same stimuli intensities, depending on their contextual position in the series of either low or high intensity stimuli, or high or low frequencies, are assessed differently by the criterion of their loudness. These loudness judgements would sometimes differ by as much as 17 dB, and it makes a very important effect if we think back to the differential threshold being approximately 1 dB. Considering these data authors conclude that such a contextual effect can not be held for a measuring artifact or subject's cognitive bias to experimental situation. Most probably we are dealing with changes in sensory processing, i.e. ..."*listening to tones of very different sound frequencies leads to the activation of essentially distinct subset of 'neural units' (distinct subchannels), and (2) the comparison of levels of activity (loudness) across different subchannels necessarily invokes contextual or relativistic information" (p. 196).*

These results really point out the need to examine the effect of stimuli context in terms of information integration. This integration can have its clear (although not known) biological underpinnings connected with the level of sensory information processing. It is not necessary, as considered in the earlier psychophysical experiments, for all the contextual effects to take place at the level of measurement error. Additional research investigating the stimuli context effect on intensity judgements are obviously necessary, specially in terms of gaining more information to associate the influencing mechanisms of context to perceived intensity. One possible direction for this research could be to investigate the similarity of stimuli context effect through different modalities.

*Stimuli context and painful stimuli*

Pain is an important part of human experience but it has not been studied much in the field of psychophysics. Probably the reason lies in the view that pain is a specific modality and when compared to the sound and vision, being much mpre loaded with emotional dimension that can constitute a disturbance in investigating its "pure" sensory intensity. *"Any measure of the threshold of pain comprised some unknown combination of the sensitivity of the subject to the painful stimulus, on the one hand, and the bias of the subject reporting that a stimulus was painful, on the other" (Irwin & Whitehead, 1991, p.230).* It is true that pain as a sensory system has its specificity because the notion of pain means a danger for an organism. When pain arises due to the external stimuli and if it is of a strong intensity, than it serves as a warning signal to the organism. Pain dominates attention very clearly and it can be considered as an instinct for survival, perhaps even more than just a pure sense.

The specificity of pain can be probably better described by stating that there is a relatively large number of cases (e.g. in comparison to vision) where there is an obvious presence of stimuli and there is no experience of pain (for example, piercing the skin with hooks and hanging on these hooks in some religious customs, see Melzack, 1973), or where the pain persists and there is no clear/visible stimulation (such as in cases of phantom limb phenomenon, see Töpfner, Wiech, Kiefer, Unertl, & Birmaumer, 2001). Algom (1992), however, states that pain should not have such a special and specific status in comparison to other modalities. He emphasizes that *"pain forms an integral part of sensory processes strictly obeying documented psyhophysical laws and processing principles" (p. 268).* But pain does have its specificity, because psychophysical and biological studies show clearly the existence of the emotional component of pain (see Price, 2002; Fernandez & Turk, 1992; Clark, Carroll, Yang, & Janal, 1986).

This brief review helps to conclude, what Fields (1999) emphasizes: "the impact of context upon somatosensory unpleasantness is potentially very large" (p. S63). This can be due, in part, to the existence of the emotional component of pain that can elevate the sensory-discriminative dimension of pain, that is, "the pure intensity", but it can also be due to the mentioned evolutionary and everyday importance that the intensity of pain has for protecting a living organism. If psychophysics wants to continue the research of contextual influence on the experience of certain stimuli, than the study of pain is seemingly very yielding. If stimuli context has its importance in the field of loudness perception, than the existence of such an influence in the field of pain research should only be more drastic. It would be interesting to know how one will perceive painful stimuli of mild intensity in the context of very painful stimuli, or stimuli not painful at all. Or how one will perceive not painful stimuli when presented in context of very painful ones. The observed effect of stimuli context can have both practical and theoretical importance. In theoretical sense it can provide new information on the relativity of experiencing pain. On the other hand, it can give useful practical information on how context can influence pain assessment in medical care system.

The aim of this study was to investigate the presence of the effect of stimuli context in experimental settings where both, painful and non-painful stimuli are present. One question was to examine the ratings of stimuli of same intensities, specifically those of the intensity below pain threshold level, in the situation when the stimuli set consists only of stimuli with their intensity below pain threshold (narrow range), in comparison to the situation when stimuli set is made out of below and above the threshold level intensities (large range). The second question deals with assessments of the same intensities, those above the pain threshold level, in the series with only above threshold intensities (narrow range) in comparison to the situation when the stimuli series consists of both, above and below pain threshold level intensities. The ratings of non-painful stimuli in the context of painful stimuli could result in significant effect of contrast. Will this effect show up for painful stimuli when perceived in the context of non-painful stimuli? If the effect is not symmetrical, the importance of the stimuli creating the stimuli context would be underlined.

This effect could be dependent on the temporal dimension of presentation of stimuli of various intensities. If the stimuli appear often, in the case of combining painful and non-painful stimuli, it could elevate the effect of stimuli context.

## METHOD

### *Design*

We conducted two separate experiments with principally the same experimental design. The only difference was which stimuli intensities were assessed in which context. The main variable of this research was the stimuli context operationally defined by a range of stimuli used. Manipulation of stimuli context by the stimuli range, for both experiments, is shown in Table 1.

Second investigated factor was the time distance (inter-stimulus interval). The inter stimulus intervals of 3 and 9 seconds were used. Therefore, the experimental design is as follow: 2 x 2 (range of stimuli - (narrow *vs*. large) x inter-stimulus interval: (3 sec *vs*. 9 sec).

### *Participants*

Independent samples of 60 subjects participated in each experiment. A number of research found a gender difference in perceiving certain stimuli as painful and non-

*Table 1*

Stimuli intensities (mA) used in Experiment 1 and in Experiment 2. Intensities of so-called *target stimuli* are marked bold, and statistical analysis was based on ratings of those stimuli intensities only.

| | | Stimuli intensities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | below pain threshold | | | | | above pain threshold | | | | |
| Experiment 1 | Narrow range | **2** | **2.5** | **3** | **3.5** | **4** | | | | | |
| | Large range | **2** | **2.5** | **3** | **3.5** | **4** | 6.5 | 7 | 7.5 | 8 | 8.5 |
| Experiment 2 | Narrow range | | | | | | **6.5** | **7** | **7.5** | **8** | **8.5** |
| | Large range | 2 | 2.5 | 3 | 3.5 | 4 | **6.5** | **7** | **7.5** | **8** | **8.5** |

*Table 2*

Experimental design in both experiments. The difference in combination of used stimuli range for each experiment is shown in Table 1. In every experimental situation were 15 participants (ISI – inter stimulus interval).

| Narrow range of stimuli | | Large range of stimuli | |
|---|---|---|---|
| ISI = 3 sec | ISI = 9 sec | ISI = 3 sec | ISI = 9 sec |
| *n*=15 | *n*=15 | *n*=15 | *n*=15 |

painful (Wise, Price, Myers, Heft, & Robinson, 2002; Giles & Walker, 2000; Riley III, Robinson, Wise, Myers, & Fillingim, 1998; Fillingim, Edwards, & Powell, 1999). Therefore, all participants were female, psychology students, aged 18-27. All were voluntarily and they receive experimental credits for their participation. They were randomly assigned to four independent stimuli sets created according to the research design. Every group had equal number of participants ($n$=15; see Table 2).

### *Apparatus and Stimuli*

Elecrocutaneous stimulation was used. A constant current stimulator (local design), delivered square-wave pulses for a fixed duration of 30 ms. Each stimulus consisted of 8 of such square-wave pulses of 250Hz frequency. Pulse shape, duration and current were calibrated and controlled by Hameg oscilloscope type HM 205-3.

Ten stimuli intensities used for the stimuli sets of the experiment were chosen based on the results of a pilot-study ($n$=5). The aim was to choose 5 stimuli that will not be painful (below pain threshold level) and 5 stimuli that will be painful (above pain threshold level). The range of the intensities was from 2 to 8 mA (see Table 1).

### *Procedure*

The stimuli were given to the upper fist. Electrodes were connected to the upper part of the fist, at the half of $2^{nd}$ and $5^{th}$ metacarpal bone (ossa metacarpalia). A total of 100 stimuli was given to each participant. The stimuli were organised in 5 groups of 20 stimuli. After every series of 20 stimuli, participants were given a short break of 1 minute. Depending on the experimental condition to which the participant was assigned, there was different stimuli intensities.

In the first experiment, a narrow range assigned 5 stimuli intensities below pain threshold level (see Table 1). Each intensity was given 20 time in quasi-random order. In the large range of first experiment, participants were given 100 stimuli, where the intensity of 50 of these stimuli was below pain threshold level and the intensity of the remaining 50 stimuli was above pain threshold level. Fifty stimuli below the pain threshold level were *target* stimuli. Only the intensity ratings for these stimuli were taken into further analysis. This enabled us to check the mean ratings differences of non-painful stimuli intensities considering the stimuli context they were presented in (see Table 1).

Experiment 2 consisted, mainly, of the same stimuli condition as that of experiment 1. The only difference is that in this experiment the narrow stimuli range was above pain threshold intensities, and the large range consisted of painful and non-painful stimuli (see Table 1). The difference in intensity ratings of painful stimuli depending on their stimuli context could be observed.

According to our experimental design (Table 2), half of the participants experienced a 3 seconds time interval between stimuli presentation, and the other half 9 seconds.

### *Pain intensity measure*

Category scale was used to assess the perceived intensity (see Figure 1). This way of measurement of perceived intensity is often employed in psychophysical research (see Gescheider, 1997), and especially in research investigating intensity of pain in either experimental or clinical situations (Gracely, 1989; Borg, E. and Borg, B. 1998; Borg, B., & Borg, E. 1998; Horn & Munafo, 1997; Urban, Keefe, & France, 1994). The choice of how to measure the dependent variable, that is, the intensity of sensation, is very important and it has been long discussed on which method is better, primarily because sometimes, the choice of the measurement method can be the cause of contextual effects (Gescheider, 1997; Stillman, 1993; Gescheuder & Hughson, 1992; Zwislocki & Goodman, 1980). The choice of categorical ratings in this research was based on the following principles: compared to magnitude estimation, where the measure is dependent on stimuli context manipulation, Ellermeier and Westphal (1991) found that the categorical ratings scale is highly reliable and no biased by the influence of stimuli context manipulation. On the other hand, we wanted to employ a measurement method similar to that employed in the "research field" of pain.

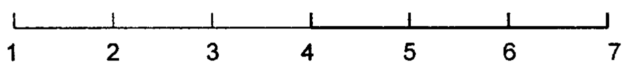


*Figure 1.* Categorial ratings scale used in these experiments. The meaning of categories was additionally explained. 1 – Experience of low-intensity stimulus; 4 - Experience of just painful stimulus; 7 – Experience of very painful stimulus. Continuum of experiencing pain was marked red on the scale (here bold).

## RESULTS

In order to control current sequential effects which can be due to the intensity of previously presented stimulus (e.g. n-1, n-2, and the like, see Ward, 1973; Gescheider, 1997), only ratings of so-called *target* stimuli were observed. In experiment 1, those were stimuli below pain threshold, and in experiment 2 stimuli above the pain threshold (see Table 1).

Considering the experimental design, an ANOVA with three factors (stimuli range x inter-stimulus interval x stimuli intensity) was conducted separately for Experiment 1, and Experiment 2.

In Experiment 1, the ratings for non-painful stimuli depends on whether they were in narrow stimuli range (all stimuli were non-painful) or in large stimuli range (50 % of stimuli were painful). There was a statistically significant main effect of stimuli range ($F(1,56) = 2.53; p<001$; Figure 2), that is, mean ratings of non-painful stimuli is significantly higher in narrow range. Stimuli range for painful target stimuli did not have a statistically significant effect on mean ratings in Experiment 2 ($F(1,56) = 0.66; p< .05$; see Figure 2).

The effect of stimuli context for non-painful stimuli is under the influence of contrast, that is, non-painful stimuli of weak intensity are rated less intensive when combined with painful stimuli. Considering that stimuli context did have an influence in Experiment 1, and did not in Experiment 2, it means that it makes a difference which stimuli form the context. That can imply that different stimuli intensities in Experiment 1 and 2 can be under different influence of stimuli context. For this reason the interaction effect between stimuli range and stimuli intensity was calculated, separately for each experiment. Statistically significant interaction effects were found in both experiments (in Experiment 1 $F(4.224)=21.6; p<.001$, and in Experiment 2 $F(4,224)=8.42; p<.001$) and they are shown in Figure 3. On the same figure is also shown the main effect of stimulus intensity, which is statistically significant for the Experiment 1 ($F(4,224)=316.2; p<.001$, and for the Experiment 2 as well $F(4,224) = 234.6; p<.001$).

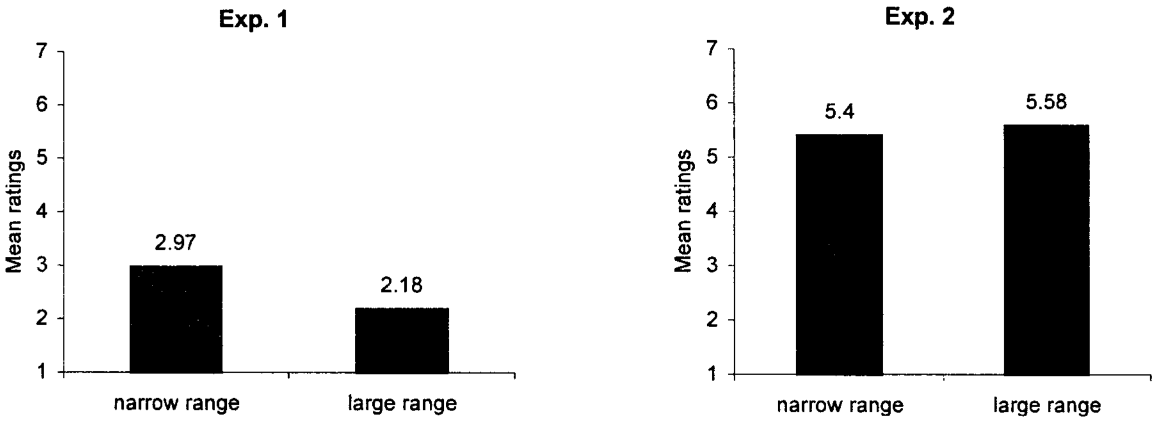


*Figure 2.* Mean ratings of stimuli intensities in Experiment 1 and 2.

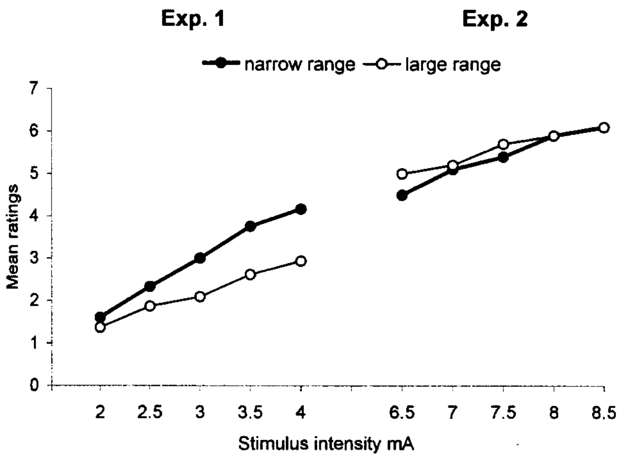


*Figure 3.* Interaction effect (stimulus intensity x stimuli context). There are significant interaction in both experiments.

Figure 3 depicts the real influence of different stimuli context on ratings of different stimuli intensities. The interaction between stimuli range and stimuli intensity is in both experiments basically the same. The only difference is that the interaction effect is stronger in Experiment 1. In both experiments, the interaction effect shows the contrast effect. In Experiment 1, non-painful stimuli intensities are underestimated when combined with painful stimuli (large range), compared to the situation when painful stimuli are not present (narrow range). The lower are the stimuli intensities, the weaker is the effect (see Figure 3).

In Experiment 2, painful intensities are rated as more painful when in the large range than in the narrow range, and this result points to the contrast effect. But this is the case for some stimuli only. In other words, the stimuli context effect is not present for the most painful stimuli, and for the two more intensive stimuli there is practically no difference in intensity ratings considering stimuli range (see Figure 3). This trend prove to be basically the same in both experiments: extreme stimuli, whether the weakest or the most painful, are least liable to the stimuli context effect.

The inter-stimulus interval effect (interval between 3 or 9 seconds) was also tested. Results show that there is no ISI effect, neither when the target stimuli are below the pain threshold ($F(1,56) = 0.25; p>.05$), nor when they are painful ($F(1,56) = 0.36; p>.05$). There is also no interaction effect between stimuli range and ISI, neither in Experiment 1 ($F(1,56) = 1.46; p>.05$), nor in Experiment 2 ($F(1,56) = 1.69; p>.05$). The only statistically significant interaction effect between stimuli intensity and ISI is the one for the painful stimuli in Experiment 2 (see Figure 4). Although the effect is statistically significant, it is not very strong. The graph shows a systematic tendency in which the stimulus intensities are rated somewhat as less intensive when the inter-stimulus interval is longer. This tendency, which points to the interaction effect, is not present for all stimuli intensities, and it is the strongest for the weakest intensity. This results show also that the strongest stimuli intensities have the highest resistance to the experimental manipulation.

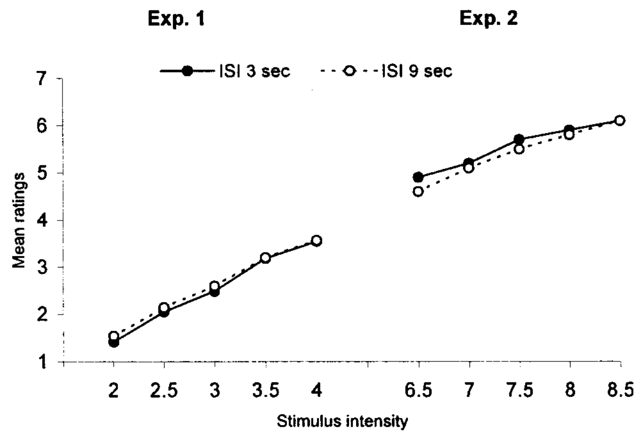


*Figure 4.* Interaction effect (stimulus intensity x inter-stimulus interval). There is significant interaction only in Experiment 2.

## DISCUSSION

The most common way of manipulating stimuli context in psychophysical research is by using a different stimuli range. In this research that kind of manipulation has partially shown significant effect which can be described as a contrast effect. Similar contrast effects were shown in similar studies in the field of ratings of loudness perception (Gescheider & Hughson, 1991; Gescheider, Bolanowski, & Verillo, 1992; Marks, 1993, 1992, 1988; Schneider & Parker, 1990). The contrast effect can be interpreted within the theoretical concept of the adaptation–level theory (Helson, 1964). According to Helson, a stimulus is perceived and judged within a frame of reference determined by the adaptation level established by the frame of reference determined by the values of other stimuli present in the situation (context). The observer's perception and subsequent judgements of sensory magnitude is determined by the adaptation level established by the frame of reference. In Experiment 1, in the large stimuli range condition, the adaptation level is higher, and this can be the reason why the non-painful stimuli are rated as even weaker (contrast in the direction of established adaptation level).

But, on the other hand, the stimuli context effect in Experiment 1 could be described as a relation between stimuli range and the magnitude of psychophysical function exponent. Poulton (1968) showed that there is a stable relation between stimuli range and psychophysical function exponent. The narrower the stimuli range is, the higher is the exponent. That kind of relation can be observed in the results of Experiment 1 (Figure 3). However, this interpretation is more appropriate for the results obtained by using the magnitude estimation method, where the participants have the tendency to use the same range of numerical ratings for different stimuli ranges, that is, most accounts treat range effects as examples of ''response bias''.

In fact, results of these experiments can not be adequately placed in neither of these two models which explain the effects of stimuli range. The essential reason for that is that the results from both experiments are basically not consistent. In other words, the effect of stimuli context depends on which stimuli are rated in which context. When it comes to the results of these experiments, painful stimuli are less liable to contextual effects, that is, their ratings are less dependent upon other stimuli in a series. This result can be observed in terms of evolution postulates of pain. Painful sensation is essential for the survival of organisms in a potentially hostile environment. ''*Nococeptive pain, once it is present, once the alarm has gone off, so dominates attention that it is more like a motivational drive than a sensation...*'' (Scholz & Wolf, 2002, p. 1062). When the participants rate the intensity of painful stimuli, then the presence of non-painful stimuli as an additional context has no significant influence on their ratings. These non-painful stimuli are irrelevant in presence of painful stimuli and, as such, they don't represent stimuli context (Experiment 2). But when the participants rate the intensity of non-painful stimuli, the presence of painful stimuli has a significant influence on the intensity ratings. In that case, significant contrast effect appears (Experiment 1). Furthermore, the results of these experiments (in both cases) are also specific in finding that for different stimulus intensities, contrast effect is different, that is, the contrast is not the same for all stimuli intensities. This is supported by significant interaction effect between stimuli intensity and stimuli context. It turned out that the stimuli from the middle of the range – the strongest non-painful stimuli and the weakest painful stimuli – are most dependent upon the different stimuli context. This result is also inconsistent with adaptation-level theory. According to this theory, the differences should be the same for all the intensity levels (see e.g. Marks, 1993). Furthermore, if this is a matter of contrast effect, then the effect, if it already exists, should be stronger for more extreme stimuli intensities. In these experiments the results show that, when it comes to that kind of stimuli (extreme stimuli), the context effect is the weakest. As Marks (1993) noted: ''*...contextually comes in a variety of flavors*'' (p. 264), and there is probably more than one mechanism of contextual effects. Principally, they can appear due to ''response bias'', but it is possible that they can also be caused by the changes in perception. Painful stimuli, when combined with non-painful ones, probably evoke such different possible mechanisms of stimuli context effects. Mechanism of environmental information integration depends upon the stimuli context and more specific relations are yet to be established. The traditional psychophysics assumed without question that nature laws are psychophysical law. But the psychophysical law is inherently too narrow to solve its own central problem, namely, measuring psychological sensation. Interpretation of stimuli as painful or non-painful introduces an additional dimension of perceiving stimuli intensity. From the point of integration psychophysics (Anderson, 2001), ''the concept of psychophysical law has been a historic misdirection. Being a function of a single variable, the psychophysical law is inherently too narrow to provide a foundation for psychophysics/perception'' (p. 182).

## REFERENCES


ALGOM, D. (1992). Psychophysical Analysis of Pain: A Functional Perspective. In H-G. Geissler, S.W. Link, & J.T. Townsend (Eds.), *Cognition, information processing, and psychophysics: basic issues* (pp. 267-291). Hillsdale: Lawrence Erlbaum Associates, Publishers.

ALGOM, D., & MARKS, L.E. (1990). Range and Regression, Loudness Scales, and Loudness Processing: Toward a Context-Bound Psychophysics. *Journal of Experimental Psychology. Human Perception and Performance, 16 (4)*, 706-727.

ANDERSON, N.H. (2001). Context effects as foundation for unified theory. *Proceedings of the Seventeenth Annual Meeting of the International Society of Psychophysics* (179-185). E. Sommerfeld, R. Kompass, T. Lachmann (Eds.), Berlin: Pabst Science Publishers.

ANDERSON, N.H. (1992). Integration Psychophysics and Cognition. In D. Algom (Ed), *Psychophysical Approaches to Cognition* (pp. 13-113). Amsterdam: North-Holland.

ANDERSON, N.H. (1975). On the Role of Context Effects in Psychophysical Judgments. *Psychological Review, 82 (6)*. 462-482.

BORG, E., & BORG, G. (1998). Absolute ME compared with natural CR scaling. In Grondin, S., & Lacoutere, Y. (Eds.) Fechner Day 98. *Proceedings of the Fourteenth Annual Meeting of the International Society for Psychophysics* (pp. 199-204). Québec, Canada: The International Society for Psychophysics.

BORG, G., & BORG, E. (1998). Natural level identification – category-ratio scaling and the centimax (cm) scale. In Grondin, S., & Lacoutere, Y. (Eds.) Fechner Day 98. *Proceedings of the Fourteenth Annual Meeting of the International Society for Psychophysics* (pp. 205-209). Québec, Canada: The International Society for Psychophysics.

CLARK, C.W., CARROLL, J.D., YANG, J.C., & JANAL, M.N. (1986). Multidimensional Scaling Reveals Two Dimenskons of Thermal Pain. *Journal of Experimental Psychology: Human Perception and Performance, 12 (1)*, 103.107.

CROSS, D.V. (1973). Sequential dependencies and regression in psychophysical judgments. *Perception & Psychophysics, 14*, 547-552.

ELLERMEIER, W., & WESTPHAL, W. (1991). On the «absoluteness» of category and magnitude scales of pain. *Perception & Psychophysics, 49 (2)*, 159-166.

FERNANDEZ, E., & TURK, D.C. (1992). Sensory and Affective Components of Pain: Separation and Synthesis. *Psychological Bulletin, 112 (2)*, 205-217.

FIELDS, H.L. (1999). Pain: an unpleasant topic. *Pain Supplement 6*, S61-S69.

FILLINGIM, R.B., EDWARDS, R.R., & POWELL, T. (1999). The relationship of sex and clinical pain to experimental pain responses. *Pain, 83*, 419-425.

GESCHEIDER, G.A., & HUGHSON, B.A. (1991). Stimulus context and absolute magnitude estimation: A study of individual differences. *Perception & Psychophysics, 50*, 45-57.

GESCHEIDER, G.A., BOLANOWSKI, S.J., & VERRILLO, R.T. (1992). Sensory, Cognitive and Response Factors in the Judgment of Sensory Magnitude. In D. Algom (Ed.), *Psychophysical Approaches to Cognition* (pp.575-621). Amsterdam: North-Holland.

GESCHEIDER, G.A. (1997). *Psychophysics: The Fundamentals* (3rd edition). Mahwah: LEA.

GILES, B.E., & WALKER, J.S. (2000). Sex differences in pain and analgesia. *Pain Reviews, 7*, 181-193.

GRACELY, R.H. (1999). Pain measurement. *Acta Anaestehsiologica Scandnavica, 43*, 897-908.

GRACELY, R.H. (1989). Methods of testing pain mechanisms in normal man. In P.D. Wall, & R. Melzack (Eds.), *Textbook of Pain* (pp. 257-267). Edinburgh: Churchill & Livingstone.

HELSON, H. (1964). *Adaptation-Level Theory.* New York: Harper & Row Publishers.

HORN, S., & MUNAFO, M. (1997). *Pain: theory, research, and intervention.* Buckingham: Open University Press.

IRWIN, R.J., & WHITEHEAD, P.E. (1991). Towards an objective psychophysics of pain. *Psychological Science, 2 (4)*, 230-235.

JESTEADT, W., LUCE, R.D., & GREEN, D.M. (1977). Sequential effects in judgments of loudness. *Journal of Experimental Psychology: Human Perception and Performance, 3*, 92-104.

LOCKHEAD, G.R., & HINSON, J. (1986). Range and sequence effects in judgment. *Perception & Psychophysics, 40 (1)*, 53-61.

MARKS, L.E. (1992). The slippery context effect in psychophysics: Intensive, extensive, and qualitative continua. *Perception & Psychophysics, 51 (2)*, 187-189.

MARKS, L.E. (1993). Contextual Processing of Multidimensional and Unidimensional Auditory Stimuli. *Journal of Exerimental Psychology: Human Perception and Performance, 19 (2)*, 227-249.

MARKS, L.E., & WARNER, E. (1991). Slipery Context Effect and Critical Bands. *Journal of Experimental Psychology: Human Perception and Performance, 17 (4)*, 986-996.

MARKS, L.E. (1988). Magnitude estimation and sensory matching. *Perception & Psychophysics, 43 (6)*, 511-525.

MELZACK, R. (1973). *The Puzzle of Pain.* Harmondsworth: Penguin Books.

PARDUCCI, A. (1963). Ragne-frequency compromise in judgment. *Psychological Monographs: General and Applied, 77 (2)*, 1-50.

POULTON, E.C. (1979). Models for Biases in Judging Sensory Magnitude. *Psychological Bulletin, 86 (4)*, 777-803.

PRICE, D.D. (2000). Psychological and neural mechanisms of the affective dimension of pain. *Science, 288*, 1769-1772.

RILEY III, J.L., ROBINSON, M.E., WISE, E.A., MYERS, C.D., & FILLINGIM, R.B. (1998). Sex differences in the perception of noxious experimetal stimuli: a meta-analysis. *Pain, 74*, 181-187.

SCHNEIDER, B., & PARKER, S. (1991). Does stimulus context affect loudness or only loudness judgments? *Perception & Psychophysics, 48 (5)*, 409-418.

SCHOLZ, J., & CLIFFORD, J. W. (2002). Can we conquer pain? *Nature Neuroscience, suplement, vol. 5*, 1062-1064.

STEVENS, S.S. (1957). On the psychophysical law. *Psychological Review, 64*, 153-181.

TÖPFNER, S. WIECH, K., KIEFER, R-T. UNERTL, K., & BIRMAUMER, N. (2001). Phanthom limb pain: a report of two cases. *European Journal of Pain, 5*, 449-455.

URBAN, J.B., KEEFE, F.J., & FRANCE, R.D. (1984). Study of Psychophysical Scaling in Chronic Pain Patients. *Pain, 20*, 157-168.

WARD, L.M. (1973). Repeated magnitude estimation with a variable standard: Sequential effects and other properties. *Perception & Psychophysics, 13*, 193-200.

WISE, E.A., PRICE, D.D., MYERS, C.D., HEFT, M.W., & ROBINSON, M.E. (2002). Gender role expectations of pain: relationship to experimental pain perception. *Pain, 96*, 335-342.

ZWISLOCKI, J.J., & GOODMAN, D.A. (1989). Absolute scaling of sensory magnitudes: A validation. *Perception & Psychophysics, 28 (1)*, 28-38.

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