Review of Psychology,
2006, Vol. 13, No. 2, 87-94 UDC 159.9

Possibilities of attentional control of pain: Influence of distractive Stroop task on pain threshold and pain tolerance

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Attention has been shown to modulate pain perception, but the relationship between attention and pain perception is still not clearly understood. Two independent experiments were conducted to examine the influence of focusing attention away from painful stimulation on the pain threshold and pain tolerance. In Experiment I (37 female participants) the dependent variable was pain threshold, and in Experiment II (42 female participants) the dependent variable was pain tolerance. Distraction task was classic color-based Stroop task. Each participant participated in two experimental situations. In one experimental situation participants were experiencing noxious (painful) stimulation while doing the Stroop task, and in the other experimental situation that stimulation was not accompanied with the additional distraction task. The results show no analgesic effect of focusing attention away from painful stimulation on either pain threshold or pain tolerance. These results are not consistent with the results obtained in similar studies on the influence of attention on pain perception. Possible explanations for these results are based upon different methodological approaches and upon the importance of interaction between various psychological factors in pain perception, with the emphasis given on the expectation that distraction strategy will be effective in modulating pain perception.

Key words: attention, pain perception, Stroop task, experimental pain

There are many examples of the absence of pain in situations when the experience of pain would be expected, and there is no absolute correspondence between pain perception and nocioceptive stimulation (e.g. sport injuries or injuries during war battles) (Melzack & Wall, 1996). These examples clearly indicate that pain perception is not a linear phenomenon, i.e. representations in the central structures are not just a simple reflection of sensory input and pain is more than the expression of sensory inputs. According to the recent conception, pain is a complex sensation involving three-dimensional integration of a sensory-discriminative, an affective-motivational and a cognitive-evaluative component (Peyron et al., 1999). Each of these components can modulate the perceived intensity and level of distress, depending on their presence. Petrovic and Ingvar (2002) suggest that "one of the most potent sources of pain modulation is the brain – although these mechanisms have only sparsely been studied" (p. 1).

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According to Villemur and Bushnell (2002) attentional state is probably the most-studied of psychological variables modifiying pain experience. The rationale behind the view of attention serving as a modulating factor in pain perception is due to its suggested limited capacity. Namely, due to its limited capacity focusing of attention on some stimuli will reduce the focus on other stimuli, evaluated as less relevant in the given moment. Simply put, an organism that could not filter anything would just not work. Theoretically, it could imply that focusing attention away from the pain could be effective in reducing the perceived level of pain intensity.

A considerable number of experimental studies was carried out to investigate the role of attention in modulating pain perception. Various distraction tasks have been used in several studies, e.g. reinterpreting cold-pressor pain as pleasant (Blitz & Dinnerstein, 1971), pleasant imagery (Horan & Dellinger, 1974), evaluating slides supposedly for a subsequent recall task (McCaul & Haugtvedt, 1982), different arithmetic operations (Jaremko, 1987; Beers & Karoly, 1979; Hodes, Howland, Lightfoot, & Cleeland, 1990), and obtained analgesic effect of distraction on pain perception. McCaul and Mallot (1984) report on several experiments where imagery as a distraction strategy was manifested as effective in reducing pain perception. However, some studies report quite the opposite results, and in some studies results showed no influence of different distraction

strategies on pain threshold and/or pain tolerance (Scott & Barber, 1977; Culm, Luscomb, & Scott, 1982).

Recent studies on the role of attention in pain perception are also focused on discovering possible biological mechanisms of analgesic effects of attention. These studies have stressed anew the potential importance of cognitive factors in pain modulation. By using different distraction strategies, e.g. auditive task (Peyron et al., 1999), computerized perceptual maze test (Petrovic, Peterson, Ghatan, Stone-Elander, & Ingvar, 2000), innocuous vibratory counter-stimulation (Longe et al., 2001) or just asking participants to either focus or distract themselves by thinking of something else but the painful heat stimulation (Tracey et al., 2002), the analgesic effect of distraction strategies was obtained. When attending to a distracton task, participants' ratings of pain intensity were lower and, at the same time, the activity in pain processing areas (pain matrix - somatosensory association areas, thalamus, anterior cingulate cortex and periaqueductal gray area) was related to changes in pain perception.

Results of these studies support the relevance of attention as a cognitive factor in pain modulation. Discovering and locating specific brain areas, the activity of which appears to be related to mechanisms of attention on one side, and its analgesic effect on the other, is the key issue in understanding the role of cognitive factors in pain modulation. Furthermore, these results would imply potential benefits of likely cognitive-behavioral methods as pain-reducing procedures.

Although many studies obtained analgesic effects of distraction on pain perception, the results are still ambiguous, i.e. distraction tasks have not always been manifested as effective in modulating pain perception. These ambiguous results can imply that attention is not always an important factor in modulating pain perception.

Eccleston (1995) indicates several methodological issues which should be taken into consideration when it comes to studies relating attention and pain perception. Namely, methodological approaches in different studies dealing with the role of attention in pain modulation are quite diverse, and inconsistent results can be related to that diversity. An important methodological issue (and a possible source of inconsistency among the obtained results) is the instructions given to the participants. The expression of pain is in fact a social process. Therefore, it is very difficult to separate one's personal estimations/evaluations on *how should* one react from one's estimations of pain intensity only. For example, placebo effect, mostly investigated in pain-related research, is mainly based upon participant's expectations of a certain outcome (Price & Fields, 1999; Kirsch, 1999; Stewart-Williams & Podd, 2004) and can be related to measures of pain intensity used. When subjective ratings are used as a dependent variable in studies concerning the relationship between cognitive factors and pain perception, two outcomes are possible. For example, it can be unclear what participants are expected to do – should they rate the intensity of stimuli or the level of experienced discomfort. There is also a problem concerning the possible influence of participant's expectations. Probably the largest peril, when it comes to consistent and comparable results, is a wide range of distraction strategies used to divert attention away from pain. These strategies vary from doing arithmetic operations, pleasant imagery, reinterpreting painful stimuli, etc. The question is do all these strategies stand for the same thing and can they be, in a similar way, related to altered pain perception? Another problem related to the use of these distraction strategies is the lack of experimenter's control over participant's involvement (mental engagement) in the distraction task.

Attempt to control participant's involvement in the distraction task could provide additional information about the role of attention in pain perception modulation. It would be best if the additional (distraction) task was a well-known task in terms of its attentional demands, i.e. a task which enables direct control over participant's cognitive engagement. Just a few studies enabled the possibility of monitoring the efficacy of distraction (Villemure & Bushnell, 2002; Petrovic, Peterson, Ghatan, Stone-Elander & Ingvar,, 2000).

In our study, we attempted to take into consideration the above mentioned methodological issues. As a distraction task a classic Stroop task was used. This is an attention demanding task due to the interference caused by conflict between the meaning of the word and the color of the ink in which the word is printed (for example word *green* is printed in red ink), i.e. a participant has to make an attentional effort to be successful in this task (MacLeod, 1991, 1992). The advantage of this task is that the participants, while doing it, can be controlled in terms of their attentional focus. Namely, while doing Stroop task, participant's achievement can be monitored through measuring the time required and counting of errors they make. Bantick, Wise, Ploghaus, Clare, Smith & Tracey, (2002) used a modified Stroop task (the counting Stroop) as a distraction task while participants received painful thermal stimuli. While participants were doing the task, pain intensity ratings were significantly lower, compared to the situation when participants took a part in less demanding cognitive task. Instead of the verbal self-reports dependent variables in our research were less subjective – we used behavioral measures of pain threshold and pain tolerance. Finally, we tried to minimize participants' expectations related to the purpose of this experiment (analgesic effect of distraction) by placing the emphasis on their results on the Stroop task.

METHODS

Participants

Two separate experiments with the same experimental design were conducted. A group of 37 participants took part

in Experiment I, where the pain threshold was a dependent variable. A group of 42 participants took part in Experiment II, where the pain tolerance was dependent variable. Time interval between the two experiments was six months and participants taking part in Experiment I could not participate in Experiment II. A number of studies found gender differences in perceiving certain stimuli as painful and non-painful (Fillingim, Edwards, & Powell, 1999; Giles & Walker, 2000; Keogh, Hatton, & Ellery, 2000; Riley, Robinson, Wise, Myers, & Fillingim, 1998; Wise, Price, Myers, Heft, & Robinson, 2002). Therefore all participants were female psychology students aged 18-25. All of them participated on a voluntary basis, receiving class-credits for their participation, and were informed that they can withdraw from the experiment at any time if they wanted to. All the participants experienced electrocutaneous stimulation before the experimental procedure, and were fully informed about this stimulation not being harmful in any way. Six participants (three from each experiment) withdrew from the experiment after the initial stage. This study was approved by the Ethical Committee of the Department of Psychology, University of Zagreb.

Apparatus and Stimuli

Electrocutaneous stimulation was used. A constant current stimulator (local design) delivered square-wave pulses. The range of intensities was from 0 - 12,5 mA. Pulse shape, duration and current were calibrated and controlled by Hameg oscilloscope type HM 205-3. Stimuli were applied on the middle and ring-finger of the participant's left hand by the electrodes with the surface area of 1 cm^2.

The Stroop task (used for the purposes of focusing attention away from painful stimulation) consisted of list of 208 word printed on A4-sized paper. Five color names were used (blue, red, green, yellow and black) and they were printed in non-correspondent ink (for example the word *blue* printed in green ink). Participants' task was to quickly and accurately name the color of the ink in which the word was printed while ignoring the meaning of the word itself (color naming instead of word naming).

Design and procedure

Experimental design was basically the same in both experiments, except for the dependent variable being the pain threshold in Experiment I, and pain tolerance in Experiment II. Each participant took part in the experiment twice, with a time interval of one week. In one part of the procedure, they performed the Stroop task while experiencing painful stimulation (distraction situation – D), and in the other part they performed the Stroop task first, and only after its completition, were exposed to painful stimulation (non-distraction situation – ND - see table 1).

Table 1

Experimental design: total number of participants in both experiments is divided in two subgroups that differ in situation sequence.

Experiment		*N*	First situation	Second situation
Experiment I	Subgroup D-ND	19	D	ND
Pain threshold	Subgroup ND-D	18	ND	D
Experiment II	Subgroup D-ND	23	D	ND
Pain tolerance	Subgroup ND-D	19	ND	D

Note. D (distraction) situation – parallel painful stimulation and Stroop task; ND (non-distraction) situation – painful stimulation after completing the Stroop task

The sequence of these two situations varied accross the participants –half of them first experienced situation D, followed by situation ND, and for the other half of participants it was the other way round. Each participant took part in both situations in order to control for possible interindividual differences. Since everyone participated in both situations, this experimental design enabled the comparison of the results on both the dependent and independent basis.

Electrocutaneous stimulation was induced and controlled by the computer. The stimuli increased continuously from 0 mA onwards, in steps of 0.04 mA/s. In the beginning the stimulation was innocuous and, depending on the interindividual differences, it slowly became noxious, i.e. painful (for approximately 40 seconds this stimulation did not lead to the experience of pain). In both situations participants were instructed to terminate electrocutaneous stimulation when they first experienced pain (Experiment I – pain threshold) or when they came to the point when they could not tolerate the stimulation any longer (Experiment II– pain tolerance), respectively. To terminate the stimulation, it was enough to press the space-bar on the keyboard placed within the participant's reach. Participants were specifically instructed not to terminate the stimulation before they first experienced pain (Experiment I) or before the point when they could no longer tolerate it (Experiment II). The difference between stimuli intensities when participants first experienced pain or could no longer tolerate it in situations D and ND was the indicator of the effect of distraction task on pain perception (for pain threshold and pain tolerance, respectively).

To minimize participants' expectations regarding the purpose of this experiment, ND situation also included the Stroop task (in fact irrelevant in that situation), and the instruction given to the participants stressed the relevance of fast and accurate performance on the Stroop task in both situations. To emphasize the importance of Stroop task, participants in situation D were instructed to continue after they terminated painful stimulation. An additional reason for using the Stroop task in situation ND is the possibility that this task can induce stress, which can, by itself, lead to an independent analgesic effect (Logan, Lutgendorf, Rainville,

Sheffild, Iverson & Lubaroff, 2001). While the participants performed the Stroop task, experimenter measured the time needed to complete the list and counted errors they made while naming the colors. Every time a participant made an error, the experimenter warned her about it and she had to name the color correctly.

RESULTS

ANOVA with two factors, distraction and situation sequence (2 x 2), was conducted separately for Experiment I and Experiment II. Average stimuli intensities at which the participants terminated the stimulation in two experiments did not differ between situations D and ND (Experiment I (pain threshold) $F(1, 35) = 2.80$; $p > .05$, Experiment II (pain tolerance) $F(1, 40) = 1.26$; $p > .05$; see Figure 1). As Figure 1. shows, the difference between situations D and ND is observed to be in the expected direction, but it is too small to be statistically significant. These results imply that there was no effect of the Stroop task (distraction) neither on pain threshold nor on pain tolerance. These results do not relate to situation sequence. There is a difference between the two experiments. Average intensity for Experiment II (pain tolerance), as expected, is significantly greater than average intensity for Experiment I (pain threshold) ($F(1, 75) = 38.8$; $p < .001$). In Experiment I the effect of the subgroup is significant ($F(1, 35) = 5.19$; $p = .029$). That result is unexpected and points to a possible prior difference between the two subgroups. Total number of participants in that experiment was randomly assigned to the different situation sequence. On the average, subgroup first participating in situation D seems to be more sensitive to painful stimulation. Since there was no interaction between the subgroup and the situation sequence (Experiment I $F(1, 35) = 0.02$; $p > .05$; Experiment II $F(1, 40) = 0.54$; $p > .05$) obtained result does not interfere with the conclusion that there is no effect of distraction on pain threshold/tolerance. At the same time, obtained difference between the two subgroups in Experiment I points to the relevance of dependent research design for the purpose of controlling possible interindividual differences between the participants.

In this study, the Stroop task was chosen as a distraction task because it enables the control of participant's involvement in the task. Due to this possibility, the time needed for completing the whole list and the number of errors made while performing the task can shed additional light on the obtained pattern of results. Generally speaking, in both experiments the main effect of sequence was significant (Exp. I – $F(1, 35) = 38.7$, $p < .001$; Exp. II – $F(1, 40) = 16.3$; $p < .001$), i.e. the participants needed less time for completing the Stroop task when they did it for the second time, no matter if the painful stimulation was present while doing it, or not. At the same time, there was a statistically significant interaction found between the sequence and situations D/ND (Exp. I – $F(1, 35) = 116.1$, $p < .001$; Exp. II – $F(1, 40) = 48.6$; $p <. 001$) (see Figure 2).

In both experiments the relation between the time and D/ND situations considering the sequence effect is basically the same. Put simply, the interaction effect can be described by a different effect of the sequence, i.e. practice. That difference is greater for the subgroup that was involved in situation D first, and then in situation ND. Subgroup that first

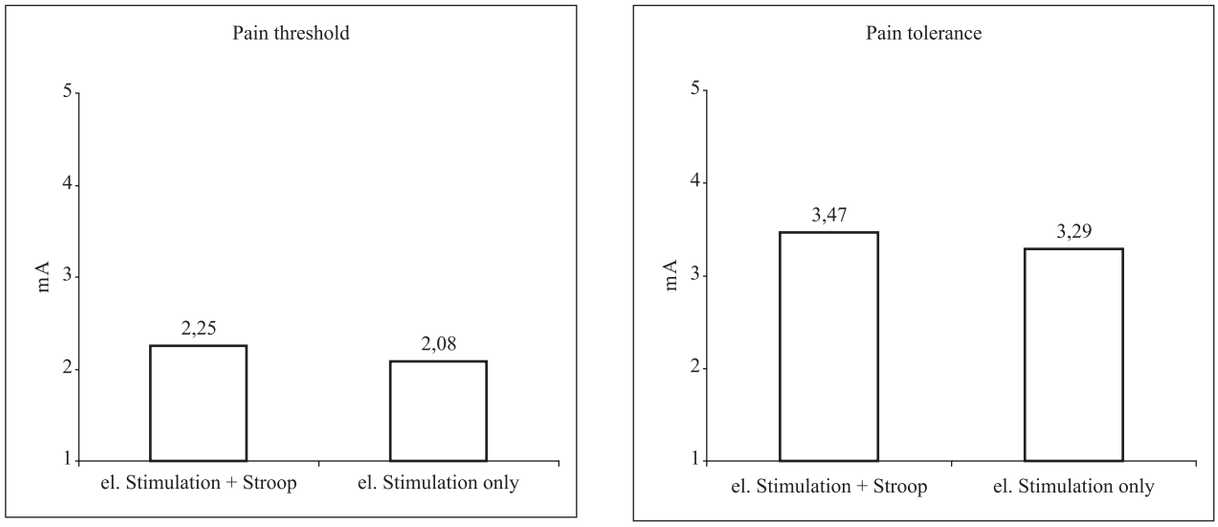

Figure 1. Average stimuli intensities of pain threshold (Experiment I) and pain tolerance (Experiment II) for two experimental situations (D and ND)

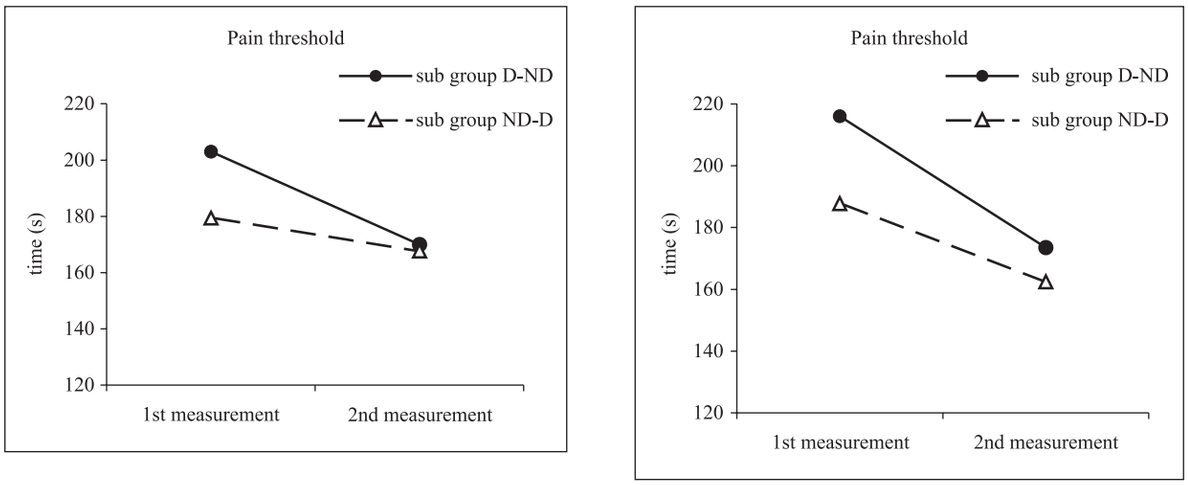

Figure 2. Average time needed for completing the Stroop task for D and ND situations in both experiments

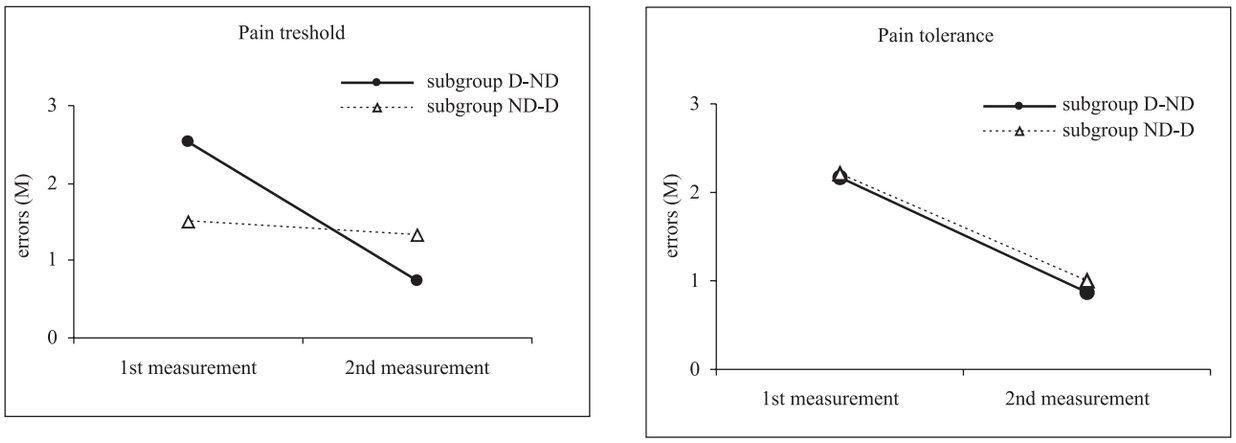

Figure 3. Average number of errors participants made while doing the Stroop task for D and ND situations in both experiments

had ND, and then situation D also needed less time to complete the Stroop task when they were doing it for the second time. This means that, in both of the experiments, performance on the Stroop task was affected by the parallel painful stimulation. The effect was greater for subgroup D/ND because in subgroup ND/D it was partially annulated by the practice, i.e. previous experience with the Stroop task.

Considering the time needed for completing the Stroop task, it is important to point out that there was no time difference found between the two experiments ($F(1, 75) = 0.50$; $p > .05$). Regardless of the fact that painful stimulation in Experiment II lasted longer on average (for approximately 30 seconds), it obviously had no effect on the generally slower performance on the Stroop task. It probably implies that in both of the experiments participants were affected by the Stroop task in the same way, taking it as relevant. In other words, it seems reasonable to assume that the participants perceived the Stroop task as the primary task and, as instructed, tried to perform as well as they could (quickly and accurately).

If additional support on perceiving the Stroop task as a primary task can be provided for both experiments then

the number of errors that participants made while doing the task would be taken into account. The total number of errors is very low (on average - 2 errors in 208 words) which implies that the participants followed instructions when it came to accuracy. There was also no difference found between the two experiments on this variable ($F(1, 75) = 0.03$; $p > .05$), indicating that different duration of electrocutaneous stimulation did not affect accuracy. Only in Experiment I the main effect of distraction was found to be significant - on the average participants performing the Stroop task while experiencing stimulation made more errors ($F(1, 35) = 7.24$; $p =. 011$). However, in both experiments the interaction between the situation sequence and distraction condition was significant (Exp. I – $F(1, 35) = 10.5$, $p < .001$; Exp. II – $F(1, 40) = 22.3$; $p < .001$). As Figure 3 shows, that relation is the same as for the time needed to complete the Stroop task. Consequently, parallel noxious stimulation had a negative influence on accuracy and that effect was smaller when the Stroop task was performed for the second time, i.e. the effect of practice had occured. Admittedly, considering a very small number of errors in general, these results are only tentative. Relatively small number of errors supports the presumption that the participants perceived the Stroop task as relevant and that they focused on performance in that task, which was the primary intention of instructional manipulation.

DISCUSSION

Obtained results indicate that there is no influence of attentional focus on either pain threshold or pain tolerance, i.e. attentional focus did not play a significant role in modulating pain perception. These results are not consistent with most of the previous studies that usually demonstrate the analgesic effect of distraction strategies on pain perception. As Eccleston points out (1995), studies addressing this problem differ in certain methodological aspects and, therefore, their conclusions can also differ. Usually, one of the key differences is the effectiveness of distraction strategy used to focus participant's attention away from pain. In this study, there are relatively reliable indicators demonstrating the effectiveness of distraction strategy in occupying participant's attention. It is not very likely that pleasant imagery reduces perceived intensity of pain (e.g. Horan & Dellinger, 1974) and that engagement in demanding cognitive task does not.

There are two possible hypotheses for explaining the results obtained in this research. First, participants were specifically instructed about the relevance of the Stroop task as a primary task. The measures of efficacy on that task (time and number of errors) partially confirm that they perceived it as relevant and primary; thus, there is a possibility that painful stimulation interfered with performance. Previous discussions and studies of the relation between attention and pain perception implied that focusing attention away from painful stimulation could decrease the perceived pain. But the question to be posed first is how and why pain demands attention. Eccleston and Crombez (1999) consider that, when it comes to relation between attention and pain perception, research should focus on that question. The important characteristic of pain is that it demands attention and interrupts all other mental activities once it occurs. The purpose of that mechanism is the protection of the organism, i.e. inducing activity that will lead to pain reduction. Thus, the presence of pain leads to underperformance on parallel activities. It is well known that in situations when chronic pain is present, the concentration and capability of learning and recalling decreased (Dufton, 1989; Schnurr & MacDonald, 1995). Consequently, results obtained in this study could imply that the participants actually terminated the painful stimulation when it started to occupy their attention and to interfere with performance on the Stroop task (which they perceived as relevant and did it very "conscientiously"). This explanation is in accordance with certain evolutionary postulates of pain. Namely, painful sensation (i.e. nociception) is essential for the survival of organisms in a potentially hostile environment. "Nociceptive pain, once it is present, once the alarm has gone off, so dominates the attention that it is more like a motivational drive than a sensation…" (Scholz & Clifford, 2002, p. 1062).

Another plausible explanation of the obtained results in this study, which are not consistent with previous studies, is based on research conducted by Devine and Spanos (1990). They mention that one of the main reasons for inconsistency of findings related to analgesic effect of cognitive factors are participants' expectations. Their study showed that participants' expectations about the level of pain, after engaging in different cognitive strategies (imagery, distraction etc), were related to participants' ratings of pain intensity. Expectations of analgesic effect of cognitive strategies on pain perception were related to their lower ratings of pain intensity after treatment. In one recent study (Wager et al., 2004), the effect of placebo on pain perception was investigated, and obtained results imply that the expectation of pain is related to a decrease of pain perception due to placebo. Expectance of pain leads to the activation of specific brain areas involved in pain anticipation (prefrontal cortex). They found that placebo analgesia was related to decreased brain activity in the pain processing areas (pain matrix) and was associated with increased activity during the anticipation of pain in the prefrontal cortex, thus providing evidence that placebo can modulate pain perception. It is important to mention one methodological issue related to research in this area. Namely, when participants are instructed, while experiencing the pain, to think of something pleasant or to reinterpret the noxious stimulation, there is a reason to assume that participants are very likely to expect that such a distraction should reduce their experience of pain, or that they can reveal the real purpose of the research and react in the expected direction. Since participants in our study were instructed that the Stroop task was primary, and our results

indicate they have followed that instruction, it allows us to conclude that instruction succeeded in minimizing participants' expectations on how distraction could lead to decrease in perceived pain intensity. Consequently, the results did not show the effect of that distraction on pain perception.

Results obtained in this study, as well as the possible explanations, imply that the relation between attention and pain perception is a complex phenomenon and that interaction approach is very important when investigating the role of cognitive factors in pain modulation. It is very likely that no single psychological factor per se contributes to the possible analgesic effect on pain perception. Only certain "positive combinations" of these factors could have that effect.

REFERENCES

Bantick, S. J., Wise, R. G., Ploghaus, A., Clare, S., Smith, S. M., & Tracey, I. (2002). Imaging how attention modulates pain in humans using functional MRI. *Brain, 125*, 310-319.

Beers, T. M,. & Karoly, P. (1979). Cognitive strategies, expectancy, and coping style in the control of pain. *Journal of Consulting and Clinical Psychology, 47*, 179-180.

Blitz, B., & Dinnerstein, A. J. (1971). Role of attentional focus in pain perception: Manipulation of response to noxious stimulation by instruction. *Journal of Abnormal Psychology, 77*, 42-45.

Culm, G. A., Luscomb, R. L., & Scott, L. (1982). Relaxation training and cognitive redirection strategies in the treatment of acute pain. *Pain, 12*, 75-83.

Devine, D. P., & Spanos, N. P. (1990). Effectiveness of maximally different cognitive strategies and expectancy in attenuation of reported pain. *Journal of Personality and Social Psychology, 58*, 672-678.

Dufton, B. D. (1989). Cognitive failure and chronic pain. *International Journal of Psychiatry Medicine, 19,* 291-297.

Eccleston, C. (1995). Chronic Pain and Distraction: An Experimental Investigation Into The Role of Sustained and Shifting Attention in The Processing of Chronic Persistent Pain. *Behavior Research and Therapy, 33*, 391-405.

Eccleston, C., & Crombez, G. (1999). Pain Demands Attention: A Cognitive-Affective Model of The Interruptive Function of Pain. *Psychological Bulletin, 125*, 356-366.

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

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

Hodes, R. L., Howland, E. W., Lightfoot, N., & Cleeland, C. S. (1990). The effects of distraction on responses to cold-pressor pain. *Pain, 41,* 109-114.

Horan, J. J., & Dellinger, J. K. (1974). "In vivo" emotive imagery: A preliminary test. *Perceptual & Motor Skills, 39*, 359-363.

Jaremko, M. E. (1987). Cognitive strategies in the control of pain tolerance. *Journal of Behavioral Therapy & Experimental Psychiatry*, *9*, 239-244.

Keogh, E., Hatton, K., & Ellery, D. (2000). Avoidance versus focused attention and the perception of pain: differential effects for men and women. *Pain, 85,* 225-230.

Kirsch, I. (1999). Specifying Nonspecifics: Psychological Mechanisms of Placebo Effects. In A. Harrington (Ed.), *The placebo effect: an interdisciplinary explanation* (pp. 12-36). Cambridge: Harvard University Press.

Logan, H., Lutgendorf, S., Rainville, P., Sheffild, D., Iverson, K., & Lubaroff, D. (2001). Effects of stress and relaxation on capsaicin-induced pain. *Journal of Pain, 2*, 60-70.

Longe, S. E, Wise, R., Bantick, S. Lloyd, D. Johansen-Berg, H. McGlone, F., & Tracey, I. (2001). Counter-stimulatory effects on pain perception and processing are significantly alerted by attention: an fMRI study. *NeuroReport, 12*, 2021-2025.

McCaul, K. D., & Malott, J. M. (1984). Distraction and Coping With Pain. *Psychological Bulletin, 95*, 516-533.

McCaul, K. D., & Haugtvedt, C. (1982). Attention, Distraction and Cold-Pressor Pain. *Journal of Personality and Social Psychology, 43*, 154-162.

MacLeod, C. M. (1991). Half a Century of Research on The Stroop Effect: An Integrative Review. *Psychological Bulletin, 109*, 163-203.

MacLeod, C. M. (1992). The Stroop Task: The "Gold Standard" of Attentional Measures. *Journal of Experimental Psychology: General, 121*, 12-14.

Melzack, R., & Wall, P. D. (1996) *The Challenge of Pain*. London: Penguin Books.

Petrovic, P., & Ingvar, M. (2002). Imaging cognitive modulation of pain processing. *Pain, 95*, 1-5.

Petrovic, P., Peterson, K. M. Ghatan, P. H. Stone-Elander, S., & Ingvar, M. (2000). Pain-relatied cerebral activation is alerted by a distracting cognitive task. *Pain, 85*, 19-30.

Peyron, R., Garccia-Larrea, L., Gregorie, M-C., Costes, N., Convers, P., Lavenne, F. Mauguiere, F., Michel, D., & Laurent, B. (1999). Haemodynamic brain responses to acute pain in humans. *Brain, 122*, 1765-1780.

Price, D. D., & Fields, H. L. (1999). The Contribution of Desire and Expectation to Placebo Analgesia: Implication for New Research Strategies. In A. Harrington (Ed.), *The placebo effect: an interdisciplinary explanation* (pp. 117-137). Cambridge: Harvard University Press.

Riley III, J. L., Robinson, M. E., Wise, E. A., Myers, C. D., & Fillingim, R. B. (1998). Sex differences in the perception of noxious experimental stimuli: a meta-analysis. *Pain, 74,* 181-187.

Schnurr, R. F., & MacDonald, M. R. (1995). Memory complaints in chronic pain. *Clinical Journal of Pain, 11*, 103-111.

Scholz, J., & Clifford, J. W. (2002). Can we conquer pain? *Nature Neuroscience, supplement, 5,* 1062-1064.

Scott, D. S., & Barber, T. X. (1977). Cognitive control of pain: Effects of multiple cognitive strategies. *Psychological Records, 2*, 373-383.

Stewart-Williams S., & Podd, J. (2004). The Placebo Effect: Dissolving the Expectancy Versus Conditionig Debate. *Psychological Bulletin, 130*, 324-340.

Tracey, I. Ploghaus, A., Gati, J. S., Clare, S. Smith, S., Menon, R. S., & Matthews, P. M. (2002). Imaging Attentional Modulation of pain in the Periaqueductal Gray in Humans. *The Journal of Neuroscience, 22*, 2748-2752.

Villemure, C., & Bushnell, M. C. (2002). Cognitive modulation of pain: how do attention and emotion influence pain processing? *Pain, 95*, 195-199.

Wager, T. D., Rilling, J. K., Smith, E. E., Sokolik, A., Casey, K.L., Davidson, R. J., Kosslyn, S. M., Rose, R. M., & Cohen, J. D. (2004). Placebo-Induced Changes in fMRI in the Anticipation and Experience of Pain. *Science, 303*, 1162-1167.

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.