

# Assessment of attention to pain using handheld computer diaries

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# Assessment of Attention to Pain Using Handheld Computer Diaries

Madelon L. Peters, PhD,\* and Geert Crombez, PhD†

\*Department of Clinical Psychological Science, Maastricht University, Maastricht, The Netherlands;

†Department of Experimental-Clinical and Health Psychology, Ghent University, Ghent, Belgium

## ABSTRACT

*Objective.* We review how handheld computer diaries may be used to measure attention to pain in daily life, and how this method helps in clarifying the relationship between attentional focusing and chronic pain.

*Results.* Signal-contingent sampling of attention to pain and pain intensity with computer diaries has demonstrated that at times when patients report increased attention to pain, they also report higher pain intensity. Time-lagged analyses assessing the temporal precedence of changes in pain and attention using computer diaries demonstrated that this association is bidirectional. One diary study manipulated attention toward or away from pain, but this manipulation proved not successful in changing pain intensity.

*Conclusion.* Signal-contingent sampling of pain and attention within patients has furthered our understanding of how these two constructs are related. Handheld computer diaries offer a flexible tool and have several advantages over traditional self-report questionnaires and paper diaries. Complex sampling schemes, in which the timing of signals, or the content of the questions may depend on previous events or responses, are possible. Future research may focus upon the application of handheld computers to measure pain and attention in therapy outcome studies, and upon the combination of event contingent sampling with time contingent sampling.

*Key Words.* Pain; Attention; Hypervigilance; Handheld Computer Diaries; Signal-Contingent Sampling

## Introduction

In this article, we review how handheld computer diaries may be used to measure attention to pain, and how they may help to clarify the relationship between attentional focusing and pain experience. We start with a brief outline of the theoretical models of the dynamic interaction between attention and pain, and how attention may play a role in the etiology and maintenance of chronic pain. Next, we review studies that have investigated the relationship between attention and pain, and especially focus upon studies using handheld computer diaries. We argue that programmable handheld computer diaries are particularly suited to provide

insight in the dynamic interrelationship between attention and pain because they allow for intensive and flexible signal-contingent assessment of the relevant constructs in daily life. Finally, we present future research directions.

## The Dynamic Interaction Between Focus of Attention and Pain

There is a dynamic and complex interaction between pain and the shift of attention from an external focus toward an internal focus. Pain often signals danger and therefore automatically demands attention and interrupts ongoing behavior to enable escape from somatic threat [1]. In turn, directing attention toward pain may increase its saliency and intensity, leading to further interference with activities.

Theoretical models on the etiology and maintenance of chronic pain disorders have emphasized

*Reprint requests to:* Madelon L. Peters, PhD, Department of Medical Clinical and Experimental Psychology, Maastricht University, PO Box 616, 6200 MD Maastricht, The Netherlands. Tel: 31-43-3881603; Fax: 31-43-3884155; E-mail: Madelon.Peters@dep.unimaas.nl.

the role of attention in pain processing. For instance, according to the fear avoidance model of chronic pain, increased attention toward pain (i.e., hypervigilance) evolving from pain-related fear is an important mechanism in maintaining and increasing pain [2]. In patients who are fearful of the consequences of pain and who catastrophize about pain, pain signals have a high threat value and an increased access to focal awareness [1]. More specifically, fear of pain and pain catastrophizing instigate a fast shifting of attention toward signals of (impending) pain, difficulties in disengaging attention from pain once it is detected and consequently difficulties of re-engaging attention with other demands in the environment [3,4].

The idea that attention to pain depends upon its threat value, and increases the salience of pain signals is largely supported by empiric data. Pain-related fear and pain catastrophizing were found to be related to increased self-reported attention toward pain, and in turn self-reported attention toward pain was associated with elevated levels of pain intensity in chronic pain patients [5,6]. In addition, laboratory studies in both healthy volunteers and chronic pain patients have confirmed that a heightened threat value of pain increases attentional demands and awareness of pain [5,7–10]. Laboratory studies have the advantage that they allow rigorous experimental control and can give evidence for causality, but a potential disadvantage of such studies is their limited generalizability toward the real life situations of persons with chronic pain.

Other studies have examined the efficacy of intentional attention management strategies to reduce the pain experience. In cross-sectional studies with pain patients, the self-reported use of distraction as a coping strategy has often been found to be associated with less intense pain [11,12], although some studies found that diverting attention away from pain was related to more severe pain [13,14]. Laboratory studies examining the effects of manipulation of attention (distraction, sensory focusing) on pain perception in healthy volunteers have also yielded inconsistent results. Some studies found distraction from pain to lead to diminished pain perception [15–18], whereas other studies found that focusing attention on the sensory components of pain to be the more effective strategy in reducing pain experience [19,20]. No effect of either distraction or sensory focusing on pain perception has also been reported [21]. It has been proposed that the effects of a particular attentional strategy may be moder-

ated by the duration of pain, the intensity of pain or individual characteristics like pain anxiety or pain catastrophizing [17,22–25]. Moreover, these experimental studies involved induction of acute pain in the laboratory and the findings may not generalize to clinical pain. There have been a few studies that assessed the effects of manipulation of attention in patients with chronic pain. Although patients with chronic pain were found to have higher pain tolerance and better task performance when distracted [26,27], distraction may have the paradoxical effect of increased pain afterwards [28]. In sum, the association between intentional attention management strategies and pain experience remains elusive.

### **Within-Person Assessment of Attention to Pain in Daily Life**

Attention to pain is a dynamic process that depends both upon the characteristics of the pain experience (e.g., its threat value) as well as upon the characteristics of other tasks that an individual pursues. Attention to pain is therefore the result of the balance between environmental task demands, task engagement, and the perceived threat of pain. Although some individuals may be more inclined than others to attend to pain signals in general, for instance because of high levels of negative affectivity [29], attention to pain is a fluctuating process that is hard to capture using retrospective self-report at a single moment in time. Likewise, chronic pain is not a steady state: the intensity of chronic pain fluctuates during the day and across days. Therefore, the study of the dynamic relationship between attention to pain and pain experience requires repeated assessment of both constructs within one single individual.

Most research so far has focused on the association between attention and pain at one single moment in time. Typically, participants fill out questionnaires based upon their memory of their experiences during a past period (e.g., last 2 weeks). These studies have yielded valuable information regarding the question whether fearful patients are generally more focused on their pain and whether such a focus results in overall higher levels of pain [5,30–33]. However, questionnaires have some disadvantages. First, they are not able to capture the dynamic interrelationship between pain and attention over time within the same individual. They only allow for analyses between individuals. One should be mindful that between-person associations do not necessarily

apply within persons. An excellent illustration of this point is the often-found associations between sadness, anxiety, and hostility across individuals [34]. However, repeated assessment of these emotions within persons has revealed that these emotional states do not co-occur at the same moment: increases in sadness are not accompanied by increased, but in contrast by reduced feelings of anxiety and anger [35,36]. In a similar vein, between-person associations between attention to pain and pain intensity do not necessarily generalize to associations within one individual at different moments in time. Diary studies allow the simultaneous investigation of both these within-person as well as between-person associations. Second, it has been shown that in retrospective assessments patients are inclined to base their estimates on the most salient or most recent experiences during a particular period [37]. Repeated assessment of pain intensity and attention to pain with a diary may then provide a more accurate picture of average pain and attention levels during a certain period of time. The fact that retrospective assessments are not the same as diary measures is shown by the moderate to weak associations between retrospective and daily reports of state variables [37–39].

In sum, the major assets of repeated assessment of pain and attention using diaries are that 1) it enables the documentation of the associations between attention and pain in the daily life of patients; 2) it allows assessment of simultaneous inter- and intra-individual associations of attention and pain; and 3) it avoids retrospective recall biases.

### Computerized Diary Assessment

Repeated data collection within a single person does not necessarily rely on computerized diary assessment but can also be obtained with paper diaries. There are several studies in chronic pain patients that have used paper diaries to collect ratings of the variables of interest (e.g., pain, mood, coping) one or a few times per day for several consecutive days (e.g., [40–44]). Usually, with such a procedure, the participant him/herself determines the exact timing of data entry, and more global rating of a state or process, aggregated over a certain time period, are obtained. This procedure may well suffice for some research questions, but for studying the dynamic interaction between attention and pain, we propose that momentary sampling, with intensive data collec-

tion at random time points, is preferable. Momentary sampling techniques like the Experience Sampling Method [45] and Ecological Momentary Assessment [46] are suitable to capture the dynamic interrelationship between two states that fluctuate in time. These methods rely on signal-contingent recording, i.e., participants are required to report on their momentary state in a diary whenever signaled. Signal-contingent diary assessment of attention to pain and pain intensity has the advantage that the experimenter determines when the self-report is due instead of the patient. This provides a more complete picture of the actual fluctuations of pain and attention in various circumstances and during different activities of daily living. Moreover, because patients are unaware of the signaling scheme, the assessment may be less biased by anticipation and less subjected to reflective responding.

The availability of programmable handheld (or palmtop) computers has greatly facilitated the employment of signal-contingent data collection in daily life. Other techniques have been used (e.g., programmable wrist watches in combination with a paper diary [47]) but computerized diaries offer several advantages. A clear advantage of handheld computer diaries is the immediate storage of data rendering manual data transfer from paper to computer superfluous, the almost unlimited memory capacity for data storage and the inability of participants to review previous entries. In addition, by date and time stamping of entries, compliance to the time scheme of sampling can be checked and fabricated data are avoided. Time stamping also gives accurate information about the interval between two subsequent entries, which may be important for tracking the time course of mutually influencing processes. Finally, programmable computer diaries enable unprecedented flexibility in tailoring questions to responses previous given or to the occurrence of specific event and they can even be used to induce certain states or prompt patients to act in a certain way. How these specific assets of handheld computer diaries may help in unravelling the complex interaction between attention and pain will be discussed below.

### Studies on Pain and Attention Using Handheld Computers Diaries

At least four studies have been performed in which computer diaries were used to obtain repeated assessment of pain intensity and attention to pain

in daily life of patients with chronic pain. Affleck et al. [48] sampled pain intensity and attention to pain three times a day for 30 consecutive days in female fibromyalgia patients using a handheld computer. They found that the between-person association between (aggregated) attention to pain scores and (aggregated) pain intensity was paralleled by a significant within-person association of pain and attention on the same day. This means that on days that patients paid more attention to their pain, they reported higher pain intensity. This finding was replicated in recent studies using handheld computer diaries to capture pain and attention, which in addition provided evidence for the hypothesized within-person association between pain-related fear and pain catastrophizing and attention to pain [49–51]. However, when attention to pain was tested as a mediator of the relation between pain-related fear and increased pain intensity, no evidence for mediation within-patients was found [51].

Another question that has been addressed by means of computerized diary assessment is whether the within-person association between attention to pain and pain intensity is moderated by individual differences in pain-related fear or catastrophizing. It may be proposed that the relationship between attention to pain and pain intensity only holds for low fearful, low catastrophizing patients, because patients with a high level of pain-related fear and catastrophizing may habitually attend to their pain and show minimal fluctuations in attention to pain [51]. Roelofs et al. tested this suggestion by measuring attention to pain and pain intensity eight times a day by means of a handheld computer diary in patients with chronic back pain. No evidence was found that differences in patients' levels of pain-related fear moderated the within-person association between attention to pain and pain intensity. However, in a recent study of Buck and Morley, evidence for the moderating effect of catastrophizing on the intraindividual relationship between focusing on pain and pain intensity was found [43]. It should be noted that this study used paper diaries to collect data three times a day (morning, afternoon, evening) and that patients were free to choose the exact time of diary completion. Several different aspects of attention to pain (“I concentrated on what the pain feels like,” “I concentrated on the pain to see if it was my normal or usual pain,” “I concentrated on the pain and thought what would happen to the pain”) were assessed. There appeared to be considerable variation in the within-person associa-

tion of pain focusing and pain intensity between different individuals, and the overall effect was not significant. However, further analyses indicated that there was a significant correlation between catastrophizing and the within-person effect. Low catastrophizing patients showed a positive association between focusing on what pain feels like and focusing on what will happen to pain and pain intensity, whereas this relationship diminished with increasing levels of catastrophizing.

To conclude, studies using handheld computer diaries have provided evidence that the previously established between-subject association between heightened attention to pain and higher pain intensity is paralleled at the within-person level. There is evidence from a study using paper diaries that this relationship may be more prominent in individuals with less catastrophizing tendencies, and it was suggested that high catastrophizing patients may attend to their pain irrespective of pain intensity. However, this suggestion needs further confirmation. The paper diary study by Buck and Morley asked for averaged rating of pain intensity and the use of coping strategies over the entire period since the last data entry. Handheld computer diaries using signal-contingent momentary assessment of the relevant variables are more capable of capturing sudden, short-lasting changes in pain intensity and the attentional focussing ratings may be less subjected to reflective responding.

#### **Diary Assessment of the Employment of Attentional Pain Coping Strategies in Daily Life**

In the previous section, we presented studies that have measured momentary fluctuations in attention to pain with handheld computer diaries. Another line of research has studied the use of the coping strategies diverting attention and/or ignoring pain using a momentary sampling procedure and relating the actual use of these strategies to fluctuations in pain intensity. Previous studies have demonstrated the importance of measuring coping on a momentary basis, mainly because there is a large discrepancy between retrospective assessment of coping and the momentary assessment of its actual use [39,52]. Studies on the association between use of the pain coping strategies “distraction from pain” and “ignoring pain” with the Coping Strategy Questionnaire [53] and diary assessment of actual employment of the strategy during a certain time period showed only moderate associations between the two measures [38,47].

There have been no studies using handheld computer diaries to assess the association between momentary attentional coping efforts and pain intensity. However, there are several paper diary studies measuring pain coping and pain intensity on a daily or within daily basis that are relevant for the present discussion as they may indicate interesting research directions for future computerized diary studies. The results of these studies can be readily summarized. First, distraction is among the most frequently used coping strategies on a daily basis [41], and women use this strategy more often than men [44]. Second, despite its frequent use, there is little evidence that it has an effect upon the pain experience. When aggregated over individuals, one study with rheumatoid arthritis patients found that the use of distraction was associated with higher pain intensity [41], whereas another study with cancer patients found distraction and ignoring pain to be unrelated to pain intensity [43]. Two daily diary studies have assessed within-person associations between the use of distraction and pain intensity in rheumatoid arthritis patients [41] and back pain patients [42]. Neither study found same day associations between distraction and pain, nor did the use of distraction on one day predict pain intensity on the next day [41].

It should be borne in mind that the interaction between pain intensity and pain coping may be very complex. High pain intensity may elicit more frequent or more intensive use of particular coping strategies, which then—when effective—may reduce pain. Thus, there may be both a negative and a positive connection between pain and coping. More sophisticated designs using frequent temporal assessment of the constructs of interest, or data sampling that is contingent on naturally occurring changes in either attentional coping or pain intensity may be more suitable to elucidate if and how distraction and pain are associated at the within-person level and what the time course of this relation is. Computerized diary assessment may enable such complex designs (see also below).

#### **Temporal Precedence of Changes in Pain and Attention: Establishing Time-Lagged Associations**

The within-person associations between attention to pain and pain intensity that have been described previously do not imply that these processes are necessarily causally linked, nor do they indicate the direction of causality. It is reasonable to assume that there will be a bidirectional connec-

tion between these two processes: high intensity pain will more easily capture attention than low intensity pain [54], and focusing attention on pain influences the pain experience [55]. Momentary sampling procedures may shed more light on this proposed bi-directional association. In their daily diary study of pain, attentional focusing and pain coping, Buck and Morley demonstrated that especially novel pain or pain in a novel location was associated with increased attention toward pain. This may imply that when pain is different from usual (e.g., more intense), it more readily grasps attention [1]. Another way in which momentary sampling procedures can be used to examine the bidirectional relationship between attention to pain and pain intensity is by looking at the temporal precedence of changes in pain and attention. Again, because of the possibility of signal-contingent intensive sampling and time stamping of the data, handheld computer diaries are particularly suited to investigate this issue. Some data pertinent to this issue will be presented here.

Affleck et al. [48] tested the bidirectional relationship between pain and attention to pain in patients with fibromyalgia who carried a handheld computer diary for 30 days and showed that the previous day's attention to pain predicted next day's pain. Previous day's pain, however, did not predict next day's attention to pain. In a computerized diary study with chronic low back pain patients, Roelofs et al. [51] tested the time-lagged associations between attention to pain and pain intensity within days, from one recording time to the next. In accordance with the finding of Affleck et al. the degree of attention to pain on a certain moment was significantly related to pain intensity on the next moment. The reverse association between pain intensity and next moment's attention to pain was not examined.

In order to investigate the time-lagged association between attention to pain and pain intensity further, we have re-analyzed two existing data sets [50,51] for the purpose of the present article. The studies of Affleck et al. [48] and Roelofs et al. [51] presented above have ignored the fact that a time-lagged association between two variables may be a reflection of trends in the data, or autocorrelation. That is, if attention to pain and pain intensity are associated at the same moment in time, there may be an association between attention at that time ( $T_0$ ) and pain at the next measurement time ( $T_1$ ) because pain at  $T_0$  is itself strongly correlated with pain at  $T_1$ . Analyses should thus correct for prior levels of the outcome variable (cf [56]). Using this

analytic approach, Turner et al. [56] demonstrated that catastrophizing predicted next moment's pain intensity even after correction for prior levels of pain intensity, but the association was substantially reduced compared with the uncorrected time-lagged association. We adopted a similar strategy in our re-analysis of the data sets.

The data were obtained from two studies using handheld computer diary assessment in chronic pain patients. In the Roelofs et al. [51] study, 40 low back pain patients were included, who carried the computer diary for 3 weeks. Only the first week of assessment is included in the present analysis as in weeks 2 and 3 an attention manipulation took place. Viane et al. [50] included 62 patients with musculoskeletal pain in their 2-week diary study. Both studies used handheld computers (Palm M100) with tailor-made software to present the questions. Diary questions were presented on screen for completion via a touch screen (50 × 50 mm) and entries were time- and date-stamped. Patients were prompted for diary entries using an audible alarm. A random time sampling procedure was used with eight signals a day delivered between 9 AM and 10 PM. For re-analyzing the data, we used multilevel regression analyses with prediction of time-lagged effects and with adjustment for prior levels of the outcome variable. For the present analyses, only within-person associations are relevant and will be presented. In both data sets, it appeared that about 50% of variance in the outcome variables (attention to pain, pain intensity) occurred on a within-person level (range: 43–60%). This means that there is as much variation in pain intensity and in attention to pain from moment to moment as there is between different patients. Both data sets assessed attention to pain with two items, with the aim of capturing

both the active component of attention (focusing on pain) and the passive component (inability to ignore pain). The two studies used slightly different wording to measure these attentional components. Roelofs et al. used the items “Right now, I am focusing on my pain” (active) and “Right now, I find it easy to ignore my pain” (passive), whereas Viane et al. used the items “Right now, I pay attention to my pain” (active) and “Right now, I can ignore my pain” (passive). For this reason, the data of these two sets were not aggregated but analyzed separately.

We first tested the association of attention to pain on T0 with pain intensity on T1. The strength of the time-lagged association between the two variables is expressed in terms of a standardized beta-coefficients. An association is significant at the  $P=0.05$  level when the standardized beta coefficient is 1.96 times larger than the standard error. Table 1 displays all significant beta coefficients together with their standard error. As can be seen in the left column of Table 1, in both data sets attention to pain on T0 significantly predicted T1 pain intensity. This means that paying attention to pain is associated with increased pain on the next moment. However, the association was not strong in the data set of Roelofs et al. When analyses were corrected for the prior level of pain, the time-lagged prediction of pain intensity by attention to pain was not significant any more in the data set of Roelofs et al. In the Viane et al. data set, the association remained significant, but decreased considerably. The table also shows that the previous pain level was by far the strongest predictor of pain intensity on the next moment.

Next, we tested the prediction of attention to pain on T1 by pain intensity on T0. The results

**Table 1** Standardized beta coefficients and standard errors for the within-patient associations of attention to pain and pain intensity

	Pain T1 (Uncorrected) Beta (SE)	Pain T1 (Corrected for Pain at T0) Beta (SE)	Pain T0 Beta (SE)
Viane et al. [50]			
I pay attention to pain T0	0.24 (0.01)	0.07 (0.01)	0.49 (0.01)
I ignore pain T0	-0.17 (0.01)	-0.04 (0.01)	-0.35 (0.01)
Pain T0		0.37 (0.01)	
Roelofs et al. [51]			
I am focusing on my pain T0	0.10 (0.03)	ns	0.22 (0.02)
I find pain easy to ignore T0	-0.10 (0.03)	ns	-0.33 (0.02)
Pain T0		0.33 (0.03)	

The left column shows the uncorrected association between attention to pain at T0 and pain intensity at T1; the middle column the association between attention to pain at T0 and pain intensity at T1 corrected for the previous level of pain intensity; the right column the same moment association between pain intensity and attention to pain.  
ns = not significant.

**Table 2** Standardized beta coefficients and standard errors for the within-patient associations of attention to pain and pain intensity

	Attention to Pain T1		Ignoring Pain T1		Focusing on Pain T1	
	(Uncorrected) Beta (SE)	(Corrected for Attention T0) Beta (SE)	(Uncorrected) Beta (SE)	(Corrected for Ignoring T0) Beta (SE)	(Uncorrected) Beta (SE)	(Corrected for Attention T0) Beta (SE)
Viane et al. [50]						
Pain intensity T0	0.24 (0.01)	0.11 (0.01)	-0.17 (0.02)	-0.07 (0.01)		
Attention/ignoring T0		0.28 (0.02)		0.25 (0.02)		
Roelofs et al. [51]						
Pain intensity T0			-0.13 (0.03)	-0.07 (0.03)	0.11 (0.02)	0.06 (0.02)
Focusing/ignoring T0				0.18 (0.03)		0.26 (0.02)

are displayed in Table 2. Again only significant beta coefficients are shown. The association between pain intensity at T0 and attention to pain at T1 was also significant. This association remained significant in both datasets even after correction for previous levels of attention to pain. But again, the association did decrease considerably and the degree of explained variance is only marginal.

To conclude, there is some evidence from these computer diary studies for a bidirectional relationship between attention to pain and pain intensity: paying attention to pain may lead to more intense pain later on, and conversely more intense pain may result in paying more attention to pain later on. It should be noted however, that the time-lagged associations are small, especially in light of the concurrent associations between pain intensity and attention to pain, which range between 0.22 and 0.49 in these data sets (see column 3 Table 1). On the other hand, the fact that there is an additional increment in pain intensity after a time point with a high level of attention to pain even after correction for pain intensity at T0 should not be disregarded. Not only is pain intensity at T0 a strong predictor of next moment's pain, it is also strongly related to the same moment's attention to pain, and through that association part of the variance of attention is partialled out. Moreover, because both studies used a random time sampling procedure the time between signals varied, with an average interval of 2 hours, but varying from 15 minutes to more than 3 hours. It may be expected that the prediction from T0 to T1 is strongest when interval times are relatively short. Using a more homogeneous or more intensive sampling scheme in future studies would possibly lead to stronger associations.

What the optimal sampling scheme would look like is yet unknown. In order to implement an adequate sampling schema, one should know the

time course of the underlying process. Another advantage of computerized diary assessment is that it may give insight in the time course of fluctuating processes because data-entry is time-stamped. When longer and shorter interval times are adequately represented, one possibility would be to use the length of the interval between signals as a predictor of the magnitude of the association. Thus, one would expect stronger associations between signals that are closer to each other in time than between more distal signals. An alternative procedure for future studies would be to use a sampling procedure in which the next signaling time is contingent on a significant change in the variable of interest. In this way, after a prominent increase in the report of attention to pain on a certain moment, the next signal can be timed after a short interval. In the same way, after a significant increase in pain intensity, the next signal can be given shortly thereafter. The availability of programmable computer diaries allows for such a flexible sampling scheme. By varying the time interval between the event of interest and the subsequent event-generated signal one could also obtain more insight in the time course of the effects.

#### Manipulation of Attention to Pain Using Handheld Computer Diaries

The establishment of the presence of time-lagged associations between attention to pain and elevated pain intensity may be taken as an indication of causal relationships, but they do not prove causality. For more definite conclusions about the causal role of increased attention to pain for heightened pain intensity, an experimental manipulation of attentional focus is required. Relatedly, to establish whether more pain leads to increased pain focusing, pain intensity should be manipulated. Programmable computer diaries may be used to implement or boost such a manipulation.



Recently we have carried out a study in which we tried to manipulate attention by means of a handheld computer diary. We studied the effect on daily reports of pain in 38 patients with chronic low back pain [57]. After one week of sampling of spontaneous fluctuations in attention to pain and pain intensity eight times a day, two different manipulations were introduced: a distraction manipulation and an attentional focusing manipulation. Each patient received both manipulations twice during a 2-week time period. The time between two manipulations was at least 2 days. Both manipulations consisted of instructions generated by the computer diary three times a day and accompanying homework assignments. In the case of the distraction manipulation, the message on the diary screen read: “pay close attention to the positive things in your environment.” The homework assignment was to take pictures from positively valenced objects or events with a photo camera that was supplied to patients and to write about these objects or events or any other positive aspects of the day. Patients also judged the esthetic value of pictures in a booklet. In the case of the attentional focusing manipulation, the instruction on the diary read: “pay close attention to your pain and other sensations today.” The homework assignment consisted of giving a description of all sensations that patients had felt during the last few hours and in addition to circle all affective and sensory words from the McGill Pain questionnaire that best described their pain (for more information on the manipulations, see the study of Roelofs et al. [57]).

The results of this study indicated that even though compliance to the procedure was good and patients themselves judged the manipulation to be effective, neither distraction nor attentional focusing influenced pain intensity. Moreover, when the scores on the attention questions in the diary were analyzed, there proved to be no difference in self-reported attention to pain (see Table 3 for an overview of results). For the purpose of the present article, additional analyses were carried out to see whether there possibly was a short-lasting effect

from distraction or focusing. We compared pain intensity and attention to pain at the first signal after initiation of the manipulation and compared this to 1) average pain intensity and attention to pain during the week without manipulations or to 2) pain intensity and attention to pain at the signal just before initiation of the manipulation. These analyses did not provide evidence for short-lasting efficacy of the manipulation. What this study does demonstrate is the difficulty of effectively altering attention to pain, even when major efforts are invested to make the manipulation as strong as possible (repeated recall of instructions, use of positive stimuli in the distraction manipulation, homework assignments). This may point to fact that attention to pain is largely unintentional and that it cannot be easily modified by controlled strategies. And important in the present context, this study can be taken as an example of how computer diaries can be used in a creative way that goes beyond their use as data collection devices only.

#### Measuring Attention to Pain in Intervention Trials: A Need for Computerized Diary Assessment?

Still another approach is to incorporate diary measures in intervention trials. Turner et al. propose that diary assessment could be particularly informative in intervention trials for chronic pain patients because they can monitor day-to-day changes in outcome variables as well as in process variables [58]. If attention to pain is an important mediator of the relation between pain-related fear and pain intensity, interventions that are effective in reducing pain-related fear should lead to a reduction of attention to pain that will precede a decline in pain intensity. If on the other hand attention to pain is reduced as a consequence of pain improvement, the decline in attention to pain would only set in after pain had decreased. So far, no study has incorporated signal-contingent computerized diary measures of both attention to pain and pain intensity in its outcome assessments. Nevertheless, some studies that have used a daily

**Table 3** Means and SD for pain intensity, focusing on pain and ignoring pain during the first week of sampling with the electronic diary when no manipulation took place, during the 2 days of distraction and during the 2 days of pain focusing. Note that scores on all three items can range from 1 to 7

	Pain Intensity	Focusing on Pain	Ignoring Pain
Week 1: no manipulation	4.45 (1.03)	2.16 (1.06)	3.89 (1.29)
Distraction manipulation	4.62 (1.23)	2.25 (1.56)	3.90 (1.36)
Focusing manipulation	4.70 (1.42)	2.29 (1.47)	3.73 (1.52)

paper diary are pertinent to this issue and will be presented here.

de Jong et al. [59] used daily (paper) diary measures of pain-related fear, pain intensity, and activity level in an repeated single case experiment on the efficacy of an exposure *in vivo* treatment in CRPS-I patients. Their data showed that the intervention under study was effective in decreasing pain-related fear and pain intensity and increasing activity level. Importantly, the daily measures clearly demonstrated that the decrease in pain-related fear preceded the decline in pain intensity. Attention to pain was not assessed in this study. In two similar studies in chronic low back pain, in which the same intervention (exposure *in vivo*) was evaluated and a comparable procedure was used, measures of attention to pain were included, but not on a daily basis [60,61]. These studies also found important declines in pain-related fear, pain intensity, and increases in daily activities. Importantly, attention to pain had also decreased after treatment, and the authors suggest that their study provides preliminary evidence “. . . for a process in which the reduction of the threat value of previously fear-eliciting stimuli (i.e., physical activity) also produced an attentional redirection away from pain and bodily sensations.” Moreover, they suggest that it is likely that the decrease in pain intensity was mediated by this attentional redirection [61]. However, unfortunately, both studies have measured attention to pain only once at pre- and posttreatment and not on a daily basis. Vlaeyen et al. therefore conclude that “Future time series analyses, perhaps with more sensitive repeated measures and smaller time intervals, looking at lagged correlations will be needed to reveal the association of changes in fear of movement/(re)injury and subsequent changes in pain vigilance, pain and disability.” Although paper diaries can be used for this purpose, computer diaries with their advanced possibility of signal-controlled and intensive assessment of fear, attention, and pain could be a valuable and practical tool to accomplish this goal.

### Conclusion and Directions for Further Research

Handheld computer diaries enable signal-contingent intensive sampling of attention to pain within an individual patient over several days to weeks. By this means, associations between attention to pain and pain intensity may be established that cannot be detected by cross-sectional measurements. Computer diaries have several advantages

over traditional paper diaries: signal-contingent sampling schemes are easily implemented, there is control over the actual time of data entry and programmable diaries enable adapting questions or signals to previous responses and events. Although a few attempts have been made to unravel the complex relationship between attention to pain and pain intensity using computer diaries, this line of research is still in its infancy and results so far are inconclusive. Nevertheless, we can cautiously conclude that at times when patients pay more attention to their pain, they also experience more pain. The link between pain and attention may work both ways: pain intensity influences next day's or next moment's attention, and attention to pain influences next day's or next moment's pain intensity.

So far, no indication for within-person associations between the use of the coping strategies distraction of attention from pain and ignoring pain and pain intensity could be established. In addition, the experimental manipulation of attention by means of a programmable computer diary with additional homework assignments proved ineffective in reducing daily attentional focusing. This may suggest that attention to pain is largely an unintentional, automatic process that is difficult to control.

We propose that fruitful approaches for further research on the issue of attention to pain using handheld computer diaries can be found in 1) studies that apply intensive signal-contingent assessment of attention to pain in therapy outcome studies; 2) studies that use the diary to induce or to support a cognitive or behavioral intervention; and 3) studies that combine event contingent sampling with time contingent sampling. This latter approach permits more intensive sampling of the variables of interest in the most relevant time frames.

Finally, a new research approach would be to examine the clinical utility of momentary sampling of attention to pain by handheld computer diaries. Monitoring cognitions, attentional focusing, and their association with pain and daily activities may increase patient's awareness of some of these relationships. Computerized data storage allows for rapid and easy feedback of recurring patterns of association. These may then be used in therapy as a starting point for challenging and modifying maladaptive cognitions and behaviors. Continuing diary assessment during therapy can subsequently indicate whether maladaptive cognitions and behaviors have successfully been modified, and

which cognitions and behaviors need further addressing. We therefore propose that computerized diary assessment of attention to pain—in addition to other relevant pain cognitions—may not only be a relevant research instrument, but may also have the potential of becoming a valuable clinical tool.

## References

- Eccleston C, Crombez G. Pain demands attention: A cognitive-affective model of the interruptive function of pain. *Psychol Bull* 1999;125:356–66.
- Vlaeyen JWS, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: A state of the art. *Pain* 2000;85:317–32.
- Van Damme S, Crombez G, Eccleston C, Roelofs J. The role of hypervigilance in the experience of pain. In: Asmundson GJG, Vlaeyen JWS, Crombez G, eds. *Understanding and Treating Fear of Pain*. Oxford: Oxford University Press; 2004:71–90.
- Crombez G, Vervaeke L, Lysens R, Baeyens F, Eelen P. Avoidance and confrontation of painful, back-straining movements in chronic back pain patients. *Behav Modif* 1998;22:62–77.
- Crombez G, Eccleston C, Baeyens F, Van Houdenhove B, Van Den Broeck A. Attention to chronic pain is dependent upon pain-related fear. *J Psychosom Res* 1999;47:403–10.
- Sullivan MJL, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and validation. *Psychol Assess* 1995;7:524–32.
- Crombez G, Eccleston C, Baeyens F, Eelen P. Attentional disruption is enhanced by the threat of pain. *Behav Res Ther* 1998;36:195–204.
- Van Damme S, Crombez G, Eccleston C. Disengagement from pain: The role of catastrophic thinking about pain. *Pain* 2004;107:70–6.
- Peters ML, Vlaeyen JW, van Drunen C. Do fibromyalgia patients display hypervigilance for innocuous somatosensory stimuli? Application of a body scanning reaction time paradigm. *Pain* 2000;86:283–92.
- Peters ML, Vlaeyen JWS, Kunnen AMW. Is pain-related fear a predictor of somatosensory hypervigilance in chronic low back pain patients? *Behav Res Ther* 2002;40:85–103.
- Jensen MP, Turner JA, Romano JM, Karoly P. Coping with chronic pain: A critical review of the literature. *Pain* 1991;47:249–83.
- Woby SR, Watson PJ, Roach NK, Urmston M. Coping strategy use: Does it predict adjustment to chronic back pain after controlling for catastrophic thinking and self-efficacy for pain control? *J Rehabil Med* 2005;37:100–7.
- Keefe FJ, Crisnon J, Urban BJ, Williams DA. Analyzing chronic low back pain: The relative contribution of pain coping strategies. *Pain* 1990;40:293–301.
- Buckelew SP, Conway RC, Shutty MS, et al. Spontaneous coping strategies to manage acute pain and anxiety during electrodiagnostic studies. *Arch Phys Med Rehabil* 1992;73:594–8.
- James JE, Hardardottir D. Influence of attention focus and trait anxiety on tolerance of acute pain. *Br J Health Psychol* 2002;7:149–62.
- Johnson MH, Petrie SM. The effects of distraction on exercise and cold pressor tolerance for chronic low back pain sufferers. *Pain* 1997;69:43–8.
- McCaul KD, Haugtvedt C. Attention, distraction, and cold-pressor pain. *J Pers Soc Psychol* 1982;43:154–62.
- Miron D, Duncan GH, Bushnell MC. Effects of attention on the intensity and unpleasantness of thermal pain. *Pain* 1989;39:345–52.
- Keogh E, Mansoor L. Investigating the effects of anxiety sensitivity and coping on the perception of cold pressor pain in healthy women. *Eur J Pain* 2001;5:11–22.
- Logan HL, Baron RS, Kohout F. Sensory focus as therapeutic treatments for acute pain. *Psychosom Med* 1995;57:475–84.
- McCaul KD, Monson N, Maki RH. Does distraction reduce pain-produced distress among college students? *Health Psychol* 1992;11:210–7.
- McCaul KD, Malott JM. Distraction and coping with pain. *Psychol Bull* 1984;95:516–33.
- Roelofs J, Peters ML, van der Zijden M, Vlaeyen JW. Does fear of pain moderate the effects of sensory focusing and distraction on cold pressor pain in pain-free individuals? *J Pain* 2004;5:250–6.
- Heyneman NE, Fremouw WJ, Gano D, et al. Individual differences and the effectiveness of different coping strategies for pain. *Cognit Ther Res* 1990;14:63–77.
- Nouwen A, Cloutier C, Kappas A, Warbrick T, Sheffield D. Effects of focusing and distraction on cold pressor-induced pain in chronic back pain patients and control subjects. *J Pain* 2006;7:62–71.
- Rode S, Salkovskis PM, Jack T. An experimental study of attention, labelling and memory in people suffering from chronic pain. *Pain* 2001;94:193–203.
- de Gier M, Peters ML, Vlaeyen JW. Fear of pain, physical performance, and attentional processes in patients with fibromyalgia. *Pain* 2003;104:121–30.
- Goubert L, Crombez G, Eccleston C, Devulder J. Distraction from chronic pain during a pain-inducing activity is associated with greater post-activity pain. *Pain* 2004;110:220–7.
- Pennebaker JW. *The Psychology of Physical Symptoms*. New York: Springer Verlag; 1982.
- Crombez G, Van Damme S, Eccleston C. Hypervigilance to pain: An experimental and clinical analysis. *Pain* 2005;116:4–7.
- Crombez G, Eccleston C, Van den Broeck A, Goubert L, Van Houdenhove B. Hypervigilance to pain in fibromyalgia: The mediating role of pain

- intensity and catastrophic thinking about pain. *Clin J Pain* 2004;20:98–102.
- 32 Ferguson RJ, Ahles TA. Private body consciousness, anxiety and pain symptom reports of chronic pain patients. *Behav Res Ther* 1998;36:527–35.
  - 33 McCracken LM. “Attention” to pain in persons with chronic pain: A behavioral approach. *Behav Ther* 1997;28:271–84.
  - 34 Watson D, Clark LA. Negative affectivity: The disposition to experience aversive emotional states. *Psychol Bull* 1984;96:465–90.
  - 35 Epstein S. A research paradigm for the study of personality and emotion. In: Page MM, ed. *Personality—Current Theory and Research*, Vol. 1. Lincoln: University of Nebraska Press; 1983:91–154.
  - 36 Larsen RJ, Ketelaar T. Personality and susceptibility to positive and negative emotional states. *J Pers Soc Psychol* 1991;61:132–40.
  - 37 Stone AA, Broderick JE, Shiffman SS, Schwartz JE. Understanding recall of weekly pain from a momentary assessment perspective: Absolute agreement, between- and within-person consistency, and judged change in weekly pain. *Pain* 2004;107:61–9.
  - 38 Peters ML, Sorbi MJ, Kruse DA, et al. Electronic diary assessment of pain, disability and psychological adaptation in patients differing in duration of pain. *Pain* 2000;84:181–92.
  - 39 Stone AA, Schwartz JE, Neale JM, et al. A comparison of coping assessed by ecological momentary assessment and retrospective recall. *J Pers Soc Psychol* 1998;74:1670–80.
  - 40 Keefe FJ, Affleck G, France CR, et al. Gender differences in pain, coping, and mood in individuals having osteoarthritic knee pain: A within-day analysis. *Pain* 2004;110:571–7.
  - 41 Keefe FJ, Affleck G, Lefebvre JC, et al. Pain coping strategies and coping efficacy in rheumatoid arthritis: A daily process analysis. *Pain* 1997;69:35–42.
  - 42 Grant LD, Long BC, Willms JD. Women’s adaptation to chronic back pain: Daily appraisals and coping strategies, personal characteristics and perceived spousal responses. *J Health Psychol* 2002;7:545–64.
  - 43 Buck R, Morley S. A daily process design study of attentional pain control strategies in the self-management of cancer pain. *Eur J Pain* 2006;10:385–98.
  - 44 Affleck G, Tennen H, Keefe FJ, et al. Everyday life with osteoarthritis or rheumatoid arthritis: Independent effects of disease and gender on daily pain, mood, and coping. *Pain* 1999;83:601–9.
  - 45 Csikszentmihalyi M, Larsen RE. Validity and reliability of experience sampling method. *J Nerv Ment Dis* 1987;175:526–36.
  - 46 Stone AA, Shiffman S. Ecological momentary assessment (EMA) in behavioral medicine. *Ann Behav Med* 1994;16:199–202.
  - 47 Lousberg R, Schmidt AJ, Groenman NH, Vendrig L, Dijkman Caes CI. Validating the MPI-DLV using experience sampling data. *J Behav Med* 1997;20:195–206.
  - 48 Affleck G, Urrows S, Tennen H, Higgins P, Abeles M. Sequential daily relations of sleep, pain intensity, and attention to pain among women with fibromyalgia. *Pain* 1996;68:363–8.
  - 49 Sorbi MJ, Peters ML, Kruse DA, et al. Electronic momentary assessment in chronic pain I: Psychological pain responses as predictors of pain intensity. *Clin J Pain* 2006;22:55–66.
  - 50 Viane I, Crombez G, Eccleston C, Devulder J, De Corte W. Acceptance of the unpleasant reality of chronic pain: Effects upon attention to pain and engagement with daily activities. *Pain* 2004;112:282–8.
  - 51 Roelofs J, Peters ML, Patijn J, Schouten EG, Vlaeyen JW. Electronic diary assessment of pain-related fear, attention to pain, and pain intensity in chronic low back pain patients. *Pain* 2004;112:335–42.
  - 52 Todd M, Tennen H, Carney MA, Armeli S, Affleck G. Do we know how we cope? Relating daily coping reports to global and time-limited retrospective assessments. *J Pers Soc Psychol* 2004;86:310–9.
  - 53 Rosenstiel AK, Keefe FJ. The use of coping strategies in chronic low back pain patients: Relationship to patient characteristics and current adjustment. *Pain* 1983;17:33–44.
  - 54 Eccleston C. Chronic pain and distraction: An experimental investigation into the role of sustained and shifting attention in the processing of chronic persistent pain. *Behav Res Ther* 1995;33:391–405.
  - 55 Arntz A, Dreessen L, Merckelbach H. Attention, not anxiety, influences pain. *Behav Res Ther* 1991;29:41–50.
  - 56 Turner JA, Mancl L, Aaron LA. Pain-related catastrophizing: A daily process study. *Pain* 2004;110:103–11.
  - 57 Roelofs J, Peters ML, Patijn J, Schouten EG, Vlaeyen JWS. An electronic diary assessment of the effects of distraction and attentional focusing on pain intensity in chronic low back pain patients. *Br J Health Psychol* 2006;11:595–606.
  - 58 Turner JA, Mancl L, Aaron LA. Brief cognitive-behavioral therapy for temporomandibular disorder pain: Effects on daily electronic outcome and process measures. *Pain* 2005;117:377–87.
  - 59 de Jong JR, Vlaeyen JW, Onghena P, et al. Reduction of pain-related fear in complex regional pain syndrome type I: The application of graded exposure in vivo. *Pain* 2005;116:264–75.
  - 60 de Jong JR, Vlaeyen JW, Onghena P, et al. Fear of movement/(re) injury in chronic low back pain: Education or exposure in vivo as mediator to fear reduction? *Clin J Pain* 2005;21:9–17.
  - 61 Vlaeyen JW, de Jong J, Geilen M, Heuts PH, van Breukelen G. The treatment of fear of movement/(re) injury in chronic low back pain: Further evidence on the effectiveness of exposure in vivo. *Clin J Pain* 2002;18:251–61.