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Objective measurement of chronic pain by a complex concentration test

ANJA BERG, KAREN OSTER, HERBERT JANIG, RUDOLF LIKAR, WOLFGANG PIPAM, ANJA SCHOLZ and KARL WESTHOFF

Higher intensity of chronic pain occurs together with the subjective experience of impaired concentration. With a complex test of concentration two facets of concentrated work can be measured reliably and validly: speed of concentrated work and percentage of concentration errors. Two studies were conducted to test whether the Complex-Concentration-Test is suitable for assessing the cognitive deficit caused by chronic pain. In Study I, 60 chronic pain patients in Germany, and in Study II, 86 patients in Austria, completed a standardized interview on pain, the Complex-Concentration-Test, the visual-analogue-scale for pain intensity, the Pain-Experience-Scale, the Pain-Disability-Index, as well as the General-Depression-Scale. The State-Trait-Anxiety-Inventory was additionally administered in Study II. The speed of concentrated work showed low, but consistent and negative correlation, with pain intensity. The percentage of concentration errors showed low to medium positive correlation with pain intensity. These correlations were not altered when age, education, depression, anxiety and use of analgesics were held constant by using partial correlations. Complex-Concentration-Test proved to be a potentially useful instrument for measuring cognitive deficit caused by chronic pain by using the percentage of concentration errors as a parameter. Therefore, it might be helpful in the assessment of the extent of impairment of an individual.

Key words: chronic pain, concentration errors, pain intensity, speed of concentrated work

Patients report that the more intense chronic pain is, the more it lowers concentration. Using different approaches, various studies revealed deficits in general cognitive functioning caused by chronic pain. Impairments were found e.g. in working memory capacity, attention and concentration (Crombez, Eccleston, Baeyens, & Eelen, 1996, 1997; Dick, Eccleston, & Crombez, 2002; Dick & Rashiq, 2007; Eccleston, 1994, 1995; Eccleston & Crombez, 1999; Grace, Nielson, Hopkins, & Berg, 1999; Grigsby, Rosenberg & Busenbark, 1995; Hart, Martelli, & Zasler, 2000).

Anja Berg, Department of Psychology, Technische Universität Dresden, Klinische Psychologie und Psychotherapie, Hohe Str. 53, 01062 Dresden, Germany. E-mail: aberg@psychologie.tu-dresden.de (the address for correspondence);

Karen Oster, Department of Psychology, Technische Universität Dresden, 01062 Dresden, Germany;

Herbert Janig, Department of Psychology, Alps-Adria University Klagenfurt, Universitätsstrasse 65, 9020 Klagenfurt, Austria;

Rudolf Likar, Pain Ambulance, Department of Anaesthesia Clinic, General Hospital Klagenfurt, St. Veiter Str. 47, 9020 Klagenfurt, Austria;

Wolfgang Pipam, Department of Psychology, Alps-Adria University Klagenfurt, Universitätsstrasse 65, 9020 Klagenfurt, Austria;

Anja Scholz, Department of Psychology, Technische Universität Dresden, 01062 Dresden, Germany;

Karl Westhoff, Department of Psychology, Technische Universität Dresden, 01062 Dresden, Germany.

In addition, chronic pain occurred with impaired attention and concentration sustained over a longer period of time (e.g. Eccleston, 1994, 1995; Roelofs, Crombez, Peters, Verschuere, & Vlaeyen, 2005). The present study examines whether a complex concentration test is suitable to describe the relation of cognitive deficit and chronic pain. This would facilitate the assessment of the extent of impairment of an individual, for example, to decide on pension entitlement.

Concentration is defined as non-automated coordination of action parts and their monitoring in a conscious and intentional way (Westhoff & Hagemeister, 2005). Concentrated work demands working as quickly as possible and at the same time accurately, something which people experience as difficult and tiring. This can be measured by concentration tests. Such a test requires coordination of perceptuomotor activity, continuous monitoring of performance, and maintenance of an optimal balance between speed and accuracy over prolonged time periods (van Breukelen, 1989). Usual concentration tests have only one type of stimuli and measure only speed of concentrated work reliably. In contrast, the Complex Concentration Test (Westhoff, 2005) consists of three subtests with different types of stimuli and includes percentage of concentration as a measure of concentration. Concentration tests with verbal, numerical as well as figural subtests are more informative (Westhoff & Scholz, 2007), being closer to requests in daily life. Percentage of concen-

tration errors is a useful concentration parameter (Hagemeister & Westhoff, 1993; Westhoff & Hagemeister, 1991, 1992) when measured over a longer period of time.

The interacting processes between concentration and chronic pain are not completely clarified. In general, people differ in their inherent concentration level. Furthermore concentration varies with current conditions. Considering subjective reports about decreased concentration occuring with chronic pain, it can be hypothesized that chronic pain may be an inhibitory condition.

Different approaches use the limited information processing capacity as a fundamental framework to describe the relation of chronic pain and concentration (Crombez et al., 1996, 1997; Eccleston, 1994, 1995; Grigsby et al., 1995; Westhoff & Hagemeister, 2005). There are impairing conditions such as pain causing lower performance in concentrated work. With a lower ability to concentrate, actions will be supplied with less power. As a result, more powerful actions from other resources will get priority, taking time and causing concentration errors (Westhoff & Hagemeister, 2005). So speed of concentrated work should be lower and percentage of concentration errors should be higher the more intense chronic pain is.

Eccleston and Crombez (1999) consider pain and cognitive task processing as competitors for the limited capacity. Processing priority is ascribed to pain in order to warn of danger and prepare for escape. Chronic pain becomes a chronic interruption of current attention although escape is not possible. It results in decreased performance on cognitive tasks. However, attentional resource models do not make predictions about performance accuracy but only about performance speed. On the other hand, limiting attention capacity has been shown to be insufficient to impair accuracy but mainly speed of performance (Sanders, 1983).

Support for the hypothesis about rivalry of attention and pain is provided by studies about brain structures involved in processing pain and cognition. The anterior cingulate cortex (ACC) with its cognitive and affective subdivisions plays an important role in emotional and cognitive pain processing and attentional mechanisms (Hart, Wade, & Martelli, 2003). These processes compete for limited processing capacity which may result in interference with cognition. Pain processing and the related emotional distress demand attention so that there is a lack of attentional resources to be allocated by ACC to further cognitive tasks.

Besides pain, conditions such as age, education and medication influence concentration performance (Westhoff, 1995). Furthermore, there is a high comorbidity between chronic pain on the one hand and depression and anxiety on the other hand (e.g. Banks & Kerns, 1996; Edwards, Auguston, & Fillingim, 2003). Regarding the mediating function of mood states like depression and anxiety in chronic pain patients, impairment of cognitive functioning is more ascribed to mood changes than to pain intensity (Hart et al., 2003; Pincus, Fraser & Pearce, 1998; Pincus & Morley, 2001). So far it has not been possible to clarify the extent of impairment mediated by mood states. This study examines the relation of pain intensity and concentration while taking into account the levels of depression and anxiety as interfering variables.

METHODS

Design

To examine the association of chronic pain and concentration, two studies based on the same correlation design were carried out. Each patient completed the same self-descriptive instruments measuring pain variables: pain intensity, pain quality, pain duration and site of pain. The second study was supplemented by the pain-related medical diagnosis. Speed of concentrated work and percentage of concentration errors were objectively measured as concentration parameters. Information about age, gender, education and use of medicine was collected for statistical control purposes. Questionnaires and tests administration was followed by a short interview about the experience of the testing, current concentration, current pain intensity and distractions during the testing.

Participants

The recruited patients in both studies had been suffering from chronic pain for more than three months. While the patients in the first study reported episodical as well as continuous pain, the chronic pain patients of the replication study suffered only from continuous pain. Patients with motor, visual and language deficits as well as patients who had current applications for pension were excluded for both studies.

The sample of Study I consisted of 60 chronic pain patients recruited from a Pain Ambulance and a joint practice of pain specialists in Germany. The 22 male and 38 female chronic pain patients had a mean age of 46 years (SD = 9 years). The following percentages show the highest education level achieved by the participants: 3 % no school graduation or less than 9 years of education, 12 % secondary school (9 to 10 years of education), 63 % apprenticeship, 20 % university-entrance exam, 2 % university degree. The median of education level in sample I is category three (apprenticeship). About 43 % of these patients described pain at one site, 43 % at multiple sites and about 13 % felt pain throughout their entire body. Back pain was reported most frequently followed by a feeling of pain in arms, legs and head. Almost half of the patients had been suffering from their pain for more than ten years. In Study II, 86 chronic pain patients were recruited from a Pain Ambulance in

Austria. The 45 female and 41 male chronic pain patients had a mean age of 48 years (*SD* = 7 years). The following percentages show the highest education level achieved by the participants: 15 % no school graduation or less than 9 years of education, 2 % secondary school (9 to 10 years of education), 61 % apprenticeship, 13 % university-entrance exam, 9 % university degree. The median of education level in sample II is category three (apprenticeship). About 13 % of these patients described pain at one site, 79 % at multiple sites and about 8 % felt pain throughout their entire body. Most patients suffered from back pain caused by protruded or slipped discs. About 44 % of the patients reported pain symptoms for more than ten years. Both samples are comparable with respect to age (t=-1.59, p=.11). While the median of education level is identical, the distribution of the further categories differs. In addition, the distribution of gender differs between the samples.

Materials

Standardized interview. The standardized interview is a self-constructed instrument. Questions are pre-determined; some answers are assessed by defined categories, others without. The interview consists of four parts. In part A, demographic information such as age, gender, education is collected. Part B is designed to gather information about chronic pain – pain location, site of pain, pain duration, current pain intensity as well as current treatment. The visual analogue scale (VAS) is included to assess current pain intensity. It is a 100 mm long line starting with "no pain" and ending with "worst imaginable pain". Part C asks for information about other physical or mental diseases as well as medication. Part D includes questions about general aspects of well-being such as current ability to concentrate, motivation, duration of sleep, quality of sleep and intake of drugs.

Questionnaires. In addition to pain-related aspects in the interview, the Pain Experience Scale (PES, Geissner, 1996) and the Pain Disability Index (PDI, Dillmann, Nilges, Saile, & Gerbershagen, 1994) were administered.

The PES allows the quantification of pain experience along two dimensions: the affective and sensory experience of pain. Both are regarded as indicators of pain intensity (Geissner, 1996). Participants rate the degree to which twenty-four pain describing adjectives are relevant for themselves on a four category rating scale. This questionnaire serves as a second, more reliable measurement of current pain intensity supplementary to VAS.

The PDI is a self-report instrument for assessing the subjective disabilities of chronic pain patients in their actual daily life. Seven items concerning familiar activities, relaxation, social activities, profession, sexuality, self-catering and essential activities are rated on a numerical rating scale of zero to ten.

Due to high comorbidity of chronic pain and depression, the General Depression Scale (GDS), the German version of the Centre for Epidemiological Studies Depression Scale (Hautzinger & Bailer, 1993), was used in this study. Containing 20 items with a four-category-rating scale, the existence of depressive symptoms and their duration in the last seven days were measured.

Considering the existing comorbidity of chronic pain-disease and anxiety disorders, the German version of the State-Trait-Anxiety-Inventory (Laux, Glanzmann, Schaffner, & Spielberger, 1981) was included in the second study. It consists of two scales, both containing 20 items and a four-category-rating scale. Scores on both scales range from 20 to 80. The State-Anxiety-scale measures situation dependent anxiety. The Trait-Anxiety-scale measures anxiety scores as a constant and situation independent feature of personality. The latter scale makes it possible to ascertain fearful-depressive irritations.

Complex Concentration Test (CCT). The Complex Concentration Test (Westhoff, 2005) measures concentration with figural, numerical and verbal subtests: (1) arrow-test, (2) arithmetic test, and (3) reversal test. Each subtest consists of five sets of tasks with increasing difficulty. In the arrow-test, arrows are presented that point in different directions and have different shapes. Participants have to mark one special kind of arrow in lines of different arrows. In the arithmetic-test, simple arithmetic tasks are presented with solutions. Participants have to decide if these solutions are false or correct. In the reversal-test, words and reversals of these words are presented. Participants must decide if the reversal is correct. CCT including instruction and practice requires 35 to 40 minutes. The two measurements of concentration in each subtest and the CCT overall were (a) speed of concentrated work measured by the number of items completed in the testing time and (b) percentage of concentration errors.

Procedure

By appointment, every patient completed all instruments individually in the same sequence: Standardized Interview, General Depression Scale (Hautzinger & Bailer, 1993), Pain Experience Scale (Geissner, 1996), Pain Disability Index (Dillmann et al., 1994), Complex Concentration Test (Westhoff, 2005), closing interview about the testing. The State-Trait-Anxiety-Inventory (Laux et al., 1981) was additionally administered to the participants of Study II after the standardized interview. Sixty to ninety minutes were required for the whole trial.

RESULTS

Pain measurements

Pain intensity was assessed by the visual analogue scale (VAS) and the Pain Experience Scale (PES). The pain dis-

Table 1
Pain Scores and concentration measurements – mean and standard deviation, difference between samples

		Study I		Study II			
		M	*SD*	*M*	*SD*	*t*	*p*
CCT [a] Overall	Speed [b]	1084.1	314.4	981.9	263.1	2.13	.04*
	Concentration errors% [c]	9.3	7.25	9.7	6.1	-0.32	.75
CCT [a] arrow-test	Speed [b]	769.8	276.4	672.2	220.1	2.28	.03*
	Concentration errors% [c]	9.0	8.9	8.9	7.2	0.07	.95
CCT [a] arithmetic-test	Speed [b]	147.0	42.0	147.5	43.7	-0.07	.94
	Concentration errors% [c]	7.1	4.8	7.0	5.3	0.06	.95
CCT [a] reversal-test	Speed [b]	167.3	47.0	162.2	52.2	0.61	.54
	Concentration errors% [c]	13.6	8.0	15.5	8.8	-1.34	.18
VAS [d]		5.0	2.7	5.7	2.5	-1.74	.08
PES affective [e]		31.8	11.6	36.8	12.0	-2.50	.01*
PES sensory [f]		20.4	7.5	24.5	7.8	-3.11	.02*
PDI [g]		39.0	13.7	36.1	14.7	1.17	.24
GDS [h]		23.9	11.1	23.6	11.5	0.16	.88
STAI [i]	Trait	-	-	47.2	13.1	-	-
	State	-	-	45.2	12.8	-	-

Note. [a] Complex Concentration Test. [b] Speed of concentrated work (number of items completed in the testing time). [c] Percentage of concentration errors. [d] Visual analogue scale (range 0 to 10). [e] Pain Experience Scale/dimension affective pain experience (range 14 to 56). [f] Pain Experience Scale/dimension sensory pain experience (range 10 to 40). [g] Pain Disability Index (range 0 to 70). [h] General Depression Scale (range 0 to 60). [i] State-Trait-Anxiety Inventory (range 20 to 80).

* Statistically significant.

ability index (PDI) was used to describe disabilities in everyday life. Table 1 shows mean and standard deviation of these measurements in both samples. VAS and PDI show no significant differences between the groups. PES affective and sensory scores were both higher in sample II. All these pain measurements do not deviate significantly from normal distribution by using Kolmogorov-Smirnov-test; but they show deviations in graphic analyses. In both studies these pain measurements reach significant ($p<.01$) inter-correlations calculated by Pearson's correlation coefficient. VAS correlates with PES affective .69 (Study I) and .61 (Study II), with PES sensory .57 (Study I) and .36 (Study II); PES affective correlates with PES sensory .69 (Study I) and .56 (Study II). The correlation of PDI with VAS is .33 (Study I) and .43 (Study II), with PES affective .44 (Study I) and .54 (Study II) and with PES sensory .44 (Study I) and .43 (Study II).

Concentration measurements

The Complex Concentration Test (CCT) was used to assess concentration performance. The Complex Concentration Test and its means and standard deviations are shown in Table 1 for both samples. There are no significant differences between the groups except for speed of concentrated work in CCT overall and speed in CCT arrow-test. Scores on both measures are higher in Sample I. In both studies all speed variables of CCT had a normal distribution, while percentage of concentration errors of CCT showed deviations from normal distribution. Concentration errors occur rarely and approximate Poisson distribution (Hagemeister & Westhoff, 1993).

Use of analgesics, measurements of depression and anxiety

Use of analgesics was classified according to the WHO guidelines for treatment of chronic pain by medication (Bader & Gallacchi, 2001): (I) non-opioid analgesics, (II) opioid-analgesics for mild to moderate pain and (III) opioid-analgesics for moderate to severe pain. In Study I, 8.3 % of the participants took no medicine against their pain and 8.3 % received medicine against their pain without any analgesics. 28.3 % took analgesics according to step I, 28.3 % step II, and 26.7 % step III. In Study II, 25.6 % of the participants took no medicine against their pain, 25.6 % took analgesics according to step I, 16.3 % step II, and 24.4 % step III. 8.1 % received medicine against their pain without any analgesics.

Results on the General Depression Scale (Hautzinger & Bailer, 1993) slightly deviate from normal distribution in both studies. In Study I, 48% of the patients had a score

of 23 or higher indicating a severe depressive disorder (*M*=23.9, *SD*=11.1). In Study II, 52.6 % of the participants had a score of 23 or higher (*M*=23.6, *SD*=11.5). The samples are comparable with respect to depression score (Table 1).

Results on the State-Trait-Anxiety-Inventory (Laux et al., 1981) are available only for the Study II sample. Both state and trait scales of STAI do not deviate significantly from normal distribution by using Kolmogorov-Smirnov-test; but they show deviations in graphic analyses. State anxiety had a mean score of 45.2 (*SD*=12.8) and trait anxiety had a mean score of 47.2 (*SD*=13.1) (Table 1).

Correlations between chronic pain and concentration performance

Relationships between chronic pain (VAS, PDI, PES) and concentration performance (CCT) were estimated by Pearson product-moment correlations (Table 2). This way of calculation has proved to be quite robust regarding violation of normal distribution. For this reason we calculated the correlations as if all variables were normally distributed.

These calculations revealed our first main result: all measurements of pain intensity correlate negatively and low with all measurements of speed of concentrated work. In Study I, there is a range from -.04 to -.23, with only two of these 16 correlations being significant. In Study II, there is a range from -.01 to -.36, with eight of 16 correlations being significant. Overall, the highest correlation can be found between speed and PES affective in Study II (CCT arithmetic-test), the lowest correlation between speed and PES affective in Study II (CCT reversal-test). Correlations with VAS and PES affective are higher in Study II except for CCT reversal-test; correlations with PES sensory and PDI are higher in Study I or similar in both studies. So there is a small but highly consistent correlation of intensity of chronic pain and speed of concentrated work. This indicates that more intense pain occurs together with lower speed of concentrated work.

Our second main result is the following: All measurements of pain intensity except for one correlate positively and low to medium with the percentage of concentration errors. This indicates that higher pain intensity occurs together with more errors of concentrated work. In Study I, there is a range from -.06 to .47, with 10 of these 16 correlations being significant. In Study II, there is a range from .09 to .49, with 11 of 16 correlations being significant. Overall, the lowest correlations can be found consistently with PDI in both studies. In Study I, correlations with PES are higher than those with VAS, while in Study II it is vice versa. In general, correlations with VAS are higher in Study II, with

Table 2
Correlations between chronic pain and performance in the Complex Concentration Test

			VAS [a]	PES affective [b]	PES sensory [c]	PDI [d]
CCT [e] overall	Speed [f]	Study I	-.22*	-.15	-.19	-.16
		Study II	-.26**	-.32**	-.12	-.07
	Concentration errors % [g]	Study I	.27*	.31**	.34**	.13
		Study II	.49**	.35**	.25**	.18
CCT [e] arrow-test	Speed [f]	Study I	-.20	-.12	-.18	-.15
		Study II	-.22*	-.31**	-.11	-.03
	Concentration errors % [g]	Study I	.26*	.28*	.28**	.15
		Study II	.39**	.29**	.18*	.14
CCT [e] arithmetic-test	Speed [f]	Study I	-.09	-.23*	-.19	-.20
		Study II	-.31**	-.36**	-.19*	-.20*
	Concentration errors % [g]	Study I	.11	.24*	.20	-.06
		Study II	.41**	.15	.13	.09
CCT [e] reversal-test	Speed [f]	Study I	-.21	-.09	-.04	-.05
		Study II	-.10	-.01	-.04	-.05
	Concentration errors % [g]	Study I	.30**	.44**	.47**	.14
		Study II	.44**	.27**	.27**	.23*

Note. Correlations were calculated by Pearson product-moment correlation. Sample size in Study I: *N*=60 for correlations of CCT with VAS, PES and *N*=56 with PDI; in Study II *N*=86 for Correlations between CCT and VAS, PES, PDI.
[a] Visual analogue scale. [b] Pain Experience Scale/dimension affective pain experience. [c] Pain Experience Scale/dimension sensory pain experience. [d] Pain Disability Index. [e] Complex Concentration Test. [f] speed of concentrated work (number of items completed in testing time). [g] Percentage of concentration errors.

**p<.01 (one-sided). *p<.05 (one-sided).

Table 3
Correlations between performance in the Complex Concentration Test and measurements of pain intensity (VAS, PES) calculated by keeping the influence of different variables constant (partial correlation)

			$r_{1;2}$ [a]	Age	Education	Depression [b]	Anxiety [c]		Use of analgesics
							state	trait	
Speed [d]	VAS [e]	Study I	-.22*	-.18	-.23*	-.19	-	-	-.17
		Study II	-.26**	-.28**	-.23*	-.20*	-.21*	-.19*	-.27**
	PES [f] affective	Study I	-.15	-.14	-.14	-.11	-	-	-.07
		Study II	-.32**	-.32**	-.30**	-.28**	-.28**	-.27**	-.33**
	PES sensory [g]	Study I	-.19	-.22*	-.16	-.15	-	-	-.15
		Study II	-.12	-.11	-.08	-.06	-.07	-.04	-.12
Concentration errors % [h]	VAS [e]	Study I	.22*	.26*	.28*	.24*	-	-	.25*
		Study II	.50**	.50**	.48**	.47**	.45**	.46**	.47**
	PES affective [f]	Study I	.32**	.31**	.32**	.29*	-	-	.29*
		Study II	.35**	.34**	.32**	.31**	.29**	.30**	.33**
	PES sensory [g]	Study I	.41**	.35**	.32**	.32**	-	-	.33**
		Study II	.25*	.24*	.21*	.20*	.19*	.19*	.24*

Note. Sample size in Study I: *N*=60 for correlation $r_{1;2}$, *N*=56 for partial correlations; in Study II: *N*=86 for all correlations.
[a] correlation between one concentration measurement and one pain measurement without statistical control by partial correlation. [b] General Depression Scale. [c] State-Trait-Anxiety-Inventory. [d] speed of concentrated work in Complex Concentration Test overall (number of items completed in testing time). [e] Visual Analogue Scale. Pain Experience Scale/dimension affective pain. [f] Pain Experience Scale/dimension affective pain experience. [g] Pain Experience Scale/dimension sensory pain experience. [h] percentage of concentration errors in Complex Concentration Test overall.
**p<.01 (one-sided). *p<.05 (one-sided).

PES sensory higher in Study I and no consistent result in PES affective.

Comparing all correlation coefficients of Table 2 across both independent samples according to Millsap, Zalkind and Xenos (1990) (two-tailed, α=.05), no significant deviations could be found except for the correlations between percentage of concentration errors in CCT arithmetic-test and VAS.

Correlations with speed of concentrated work and percentage of concentration errors in the CCT overall on the one hand and measurements of pain intensity (VAS, PES) on the other hand are calculated by keeping the influence of these variables constant (Table 3). Calculation of partial correlations requires interval scaled variables. So the interpretation of results including the ordinal scaled variables education level and use of analgesics are limited.

There is a further consistent result concerning the correlations between speed of concentrated work in CCT overall and measurements of pain: the partial correlations remain negative and are lower than the initial correlations. There are only slight differences in both studies except for consistent deviations from .04 to .08 in partial correlations with anxiety scores; in the case of significance before partial correlation the values of the partial correlations remained significant. The partial correlations between percentage of concentration errors of CCT overall and the pain measurements remain positive and significant. Again, there are consistent deviations in partial correlations with anxiety scores. In general, partial correlations cause deviations from the initial correlations ranging from .00 to .09. Again, in the case of significance before partial correlation the values of most partial correlations remained significant.

Correlations among chronic pain and age, education, depression, anxiety and use of analgesics

In addition to the partial correlations, we examined to what extent the variables age, education level, depression, state and trait anxiety and use of analgesics correlate with the pain measurements (Table 4). Spearman rank correlation coefficients were calculated for ordinal scaled variables (education level, use of analgesics), Pearson product-moment correlations for interval scaled variables (age, depression and anxiety). Slight deviations from normal distribution were accepted due to the fact that the calculation is robust regarding these deviations.

There is no remarkable relation of age to pain intensity and PDI, correlations range from -.22 to .18. Only age and PDI in study II correlate significantly. Education level correlates consistently negatively with pain measurements in both studies, but low and insignificant in Study I and medium and significant in Study II. A lower education level occurs in study II together with higher pain intensity and pain disability. Depression and anxiety scores show consistently significant positive correlations to all pain measurements

Table 4
Correlations between pain measurements and the variables age, education, depression (GDS), state and trait anxiety (STAI) and use of analgesics

		Age	Education	Depression	Anxiety		Use of analgesics
					state	trait	
VAS[a]	Study I	.18	-.06	.38**	-	-	.27*
	Study II	-.04	-.35**	.43**	.36**	.42**	.24*
PES affective[b]	Study I	.07	-.07	.41**	-	-	.44**
	Study II	.07	-.44**	.45**	.40**	.44**	.12
PES sensory[c]	Study I	-.03	-.16	.39**	-	-	.25*
	Study II	.04	-.35**	.34**	.30**	.40**	.07
PDI[d]	Study I	.05	-.09	.47**	-	-	.35**
	Study II	-.22*	-.34**	.45**	.34**	.43**	.15

Note. Spearman rank correlation coefficient was calculated for correlations with ordinal variables (education, use of analgesics), the remaining correlations were calculated by Pearson product-moment correlation.
Sample size in Study I: *N*=60 except for correlations with PDI with *N*=56; in Study II: *N*=86 for all correlations.
[a] Visual analogue scale. [b] Pain Experience Scale/dimension affective pain experience. [c] Pain Experience Scale/dimension sensory pain experience. [d] Pain Disability Index.
**p<.01 (one-sided); *p<.05 (one-sided).

ranging from .34 to .47 for depression and from .30 to .44 for anxiety. Higher pain intensity and stronger experience of disability caused by chronic pain tend to occur together with higher depression and anxiety scores. The relation of use of analgesics and pain measurements is consistently positive and significant in Study I. In Study II, the correlation values

Table 5
Correlations between measurements of concentration and age, education, depression (GDS), state and trait anxiety (STAI) and use of analgesics

			Age	Education	Depression	Anxiety		Use of analgesics
						state	trait	
CCT [a] Overall	Speed [b]	Study I	-.37**	.32**	-.14	-	-	-.21
		Study II	-.26**	.14	-.17	-.18	-.20*	.01
	Concentration errors % [c]	Study I	.18	-.30**	.29*	-	-	.10
		Study II	.16	-.27**	.17	.22*	.19*	.21*
CCT arrow-test	Speed	Study I	-.37**	.30**	-.11	-	-	-.19
		Study II	-.24*	.11	-.19*	-.21*	-.20*	.05
	Concentration errors %	Study I	.20	-.28*	.29*	-	-	.02
		Study II	.13	-.29**	.11	.16	.11	.24*
CCT arithmetic-test	Speed	Study I	-.08	.11	-.09	-	-	-.17
		Study II	-.11	.33**	-.11	-.05	-.18*	-.03
	Concentration errors %	Study I	.03	-.18	.13	-	-	.20
		Study II	.03	-.05	.12	.13	.26**	.14
CCT reversal-test	Speed	Study I	-.22*	.21	-.18	-	-	-.16
		Study II	-.21*	.04	.03	.04	-.01	-.12
	Concentration errors %	Study I	.05	-.21	.16	-	-	.28*
		Study II	.12	-.26**	.24*	.23*	.22*	.07

Note. Spearman rank correlation coefficient was calculated for correlations with ordinal variables (education, use of analgesics), the remaining correlations were calculated by Pearson product-moment correlation.
Sample size in Study I: *N*=60; in Study II: *N*=86 for all correlations.
[a] Complex Concentration Test. [b]Speed of concentrated work. [c]Percentage of concentration errors.
**p<.01 (one-sided); *p<.05 (one-sided).

are lesser than in Study I. Only the correlation with VAS is significant and comparable to Study I. For significant correlations it can be stated: higher pain scores occur together with a higher level on WHO medication level.

Correlations among concentration, age, education, depression, anxiety and use of analgesics

Correlations between concentration performance and the variables age, education, depression, anxiety and use of analgesics are shown in Table 5. Again, Spearman rank correlation coefficients were calculated for ordinal scaled variables (education level, use of analgesics), Pearson product-moment correlations for interval scaled variables (age, depression and anxiety).

Age correlates consistently negatively with speed of concentrated work ranging from -.08 to -.37. Six of eight correlations are significant. Percentage of concentration errors correlates positively with age, ranging from .03 to .20. Thus, older patients tend towards lower speed and a higher percentage of concentration errors. There are only slight differences between the two studies.

Level of education correlates positively with speed of concentrated work in both studies, with only three of eight correlations being significant. Level of education correlates negatively with percentage of concentration errors, with five of eight correlations being significant. So, patients with higher level of education tend to work faster on concentration tests and make fewer concentration errors.

Scores on the General Depression Scale (GDS) correlate negatively but low with speed in concentrated work ranging from .03 to -.19. The respective correlations with percentage of concentration errors are all positive ranging from .11 to .29, with three of eight correlations being significant. State anxiety shows negative and low correlations with speed of concentration ranging from .04 to -.21 and positive and low correlations with percentage of concentration errors ranging from .13 to .23. Correlations of trait anxiety show similar results ranging from -.01 to -.20 for speed and from .11 to .26 for percentage of errors. Nine of 16 correlations are significant. Taking more or stronger analgesics tends to correlate negatively but low with speed of concentrated work in Study I. Except for the low negative correlation to CCT reversal test, no respective correlations can be found in Study II. The correlations with percentage of concentrated work are all positive, with three of eight being significant. To sum up, patients with higher depression scores, with higher anxiety scores or with stronger analgesic medication tend to have a slower speed of concentrated work and to make more concentration errors.

DISCUSSION

In two studies, we examined whether a complex concentration test is suitable to describe the cognitive deficit caused by chronic pain. As hypothesized, we found that all measurements of pain intensity correlated negatively but low with all measurements of speed of concentrated work in a complex concentration test. The respective correlations with percentage of concentration errors were positive and low to medium.

The size of correlations differed with the measuring instruments of pain intensity and between the samples. Medium intercorrelations between the pain measurement instruments indicate that these instruments do not exactly describe the same pain aspects. These intercorrelations are comparable to the results Geissner (1996) and Dillmann et al. (1994) described in their studies. This is why comparable correlations between pain and concentration are not likely when different pain measurement instruments are used. Furthermore, varying correlations between instruments and samples are possibly due to observed different practice in using the VAS and unequal word comprehension in PES by clients. In addition, patients complained about an insufficient pain description with PES. A further general problem remains: individual differences in perception and evaluation of pain result in different qualitative and quantitative descriptions of pain. Correlations between PDI and concentration are similar low in both samples. The low correlations can be attributed to the fact that PDI assesses impaired areas of life only in a global way. So, the PDI is not sensitive enough to covariate with specific measures as concentration speed and errors.

The results remained almost the same after age, level of education, state and trait anxiety, depression and use of analgesics were held constant by using partial correlations. Only the anxiety scores reduced to some extent the correlations between pain intensity and concentration performance. Anxiety reduced the partial correlations slightly more than depression did. In both studies the well-known comorbidity of chronic pain and depression (Banks & Kerns, 1996) as well as of anxious-depressive irritations and anxiety disorders (Edwards et al., 2003) was confirmed by significant correlations. There are only low correlations of concentration performance with depression as well as with anxiety. Nevertheless, this might be a subtle hint for the hypothesis that emotions may strain the capacity of concentration and therefore interfere with concentrated working (Westhoff & Hagemeister, 2005).

Taking analgesics may impair concentration in everyday life (Westhoff & Hagemeister, 2005). Systematically negative correlations between application of more and stronger analgesics and speed of concentrated work were found in Study I only. Percentage of concentration errors seems to be more sensitive to medication influence, considering the consistent and corresponding correlations in Study I and II. Further studies could be helpful in consolidating this influence.

The results confirm the theory of concentration (Westhoff & Hagemeister, 2005) by showing the interrupting impact

of intensity of chronic pain on concentration performance. Correlations between intensity of chronic pain and speed of concentrated work are actually of theoretical importance. Further studies in which the speed of concentrated work is additionally measured in its course over time may clarify whether and to what extent the speed of concentrated work is dependent on intensity of chronic pain. The respective correlations of percentage of concentration errors, however, seem to be of more practical importance. There are indicators of intensity of chronic pain which can be measured objectively and efficiently in terms of duration and costs. The results concerning speed of concentrated work would be predicted also by the work of Eccleston (1994, 1995), Eccleston and Crombez (1999), Crombez et al. (1996, 1997) and Grace et al. (1999).

Completely new, as far as we know, is the theorizing about percentage of errors of concentration and the respective practically important correlation with intensity of chronic pain. Concentration errors can be attributed to attentional fluctuations during performance in laboratory tasks (Flehmig, Steinborn, Langner, Scholz, & Westhoff, 2007) as well as in everyday life situations (Flehmig, Steinborn, Langner, & Westhoff, 2007). This study provides further support for the idea, put forward by Eccleston and Crombez (1999) that performance characteristics of chronic pain patients are mainly due to interruptions of current information processing. We extended the body of evidence showing that performance correlates of chronic pain are not restricted to paradigms using dual-task methology but can sensitively be assessed with measures of elementary cognitive operations.

The present findings demonstrate that proneness to erroneous concentration performance is an important aspect that characterizes information processing in chronic pain. Nevertheless, practitioners in this field should not overestimate concentration errors in their assessment strategy. Since behavior is always a function of the interplay between factors within and outside the individual (Westhoff, Hagemeister, & Strobel, 2007), a well-balanced assessment strategy should integrate both psychological and non-psychological factors. With this regard, a general technology is provided for integrating information from several sources in order to aid decision making in any kind of assessment situation (Westhoff, Hagemeister, & Strobel, 2007).

To sum up, by using a correlation design we provided evidence on relations between pain intensity and concentration performance in both studies. Nevertheless, causal interpretation of results remains impossible. Furthermore, a major problem remains: many variables, such as fatigue, influence concentration. It was only possible to control a few aspects in this study. The basic research using a quasi-experimental design can now be complemented by experimental work testing chronic pain patients before and after sufficient treatment of their symptoms. If further research can confirm concentration errors as a valid indicator of chronic pain, there will be an opportunity to break ground for an elementary, user-friendly and economic diagnostic instrument for psychologists and physicians.

REFERENCES

Bader, R., & Gallacchi, G. (2001). *Schmerzkompendium. Schmerzen verstehen und behandeln* [Pain compendium. Understanding and treating pain]. Stuttgart: Georg Thieme Verlag.

Banks, S.M., & Kerns, R.D. (1996). Explaining high rates of depression in chronic pain: a diathesis-stress framework. *Psychological Bulletin*, *119*, 95-110.

Crombez, G., Eccleston, C., Baeyens, F., & Eelen, P. (1996). The disruptive nature of pain. An experimental investigation. *Behaviour Research and Therapy*, *34*, 911-918.

Crombez, G., Eccleston, C., Baeyens, F., & Eelen, P. (1997). Habituation and the interference of pain with task performance. *Pain*, *70*, 149-154.

Dick, B., Eccleston, C., & Crombez, G.(2002). Attentional functioning in Fibromyalgia, rheumatoid arthritis and musculoskeletal pain patients. *Arthritis care and research*, *47*, 639-644.

Dick, B.D., & Rashiq, S. (2007). Disruption of attention and working memory traces in individuals with chronic pain. *Anesthesia and Analgesia, 104*, 1223-1229.

Dillmann, U., Nilges, P., Saile, H., & Gerbershagen, H.U. (1994). *Behinderungseinschätzung bei chronischen Schmerzpatienten* [Assessment of disability in chronic pain patients]. *Schmerz, 8*, 100-110.

Eccleston, C. (1994). Chronic pain and attention. A cognitive approach. *British Journal of clinical psychology*, *33*, 535-548.

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. *Behaviour Research and Therapy*, *33*, 391-405.

Eccleston, C., & Crombez, G. (1999). Pain demands attention. A cognitive-affective model of interruptive function of pain. *Psychological Bulletin*, *125*, 356-367.

Edwards, R., Auguston, E., & Fillingim, R. (2003). Differential relationships between anxiety and treatment-associated pain reduction among male and female chronic pain patients. *Clinical Journal of Pain*, *19*, 208-216.

Flehmig H.C., Steinborn, M.B., Langner, R., Scholz, A., & Westhoff, K. (2007). Assessing intraindividual variability in sustained attention: Reliability, relation to speed and accuracy, and practice effects. *Psychology Science*, *49*, 132-149.

Flehmig, H.C., Steinborn, M.B., Langner, R., & Westhoff, K. (2007). Neuroticism and the mental noise hypothesis. Relation to lapses of attention and slips of action in everyday life. *Psychology Science*, *49*, 343-360.

Geissner, E. (1996). *Die Schmerzempfindungs-Skala* (SES) [The Pain Experience Scale]. Göttingen: Hogrefe.

Grace, G.M., Nielson, W.R., Hopkins, M., & Berg, M.A. (1999). Concentration and memory deficits in patients with Fibromylagia syndrome. *Journal of Clinical and Experimental Neuropsychology*, *21*, 477- 487.

Grigsby, J., Rosenberg, N.L., & Busenbark, D. (1995). Chronic pain is associated with deficits in information processing. *Perceptual and motor skills*, *81*, 403-410.

Hagemeister, C., & Westhoff, K. (1993). The First Law of Concentration Error Rate. *Proceedings of Fourth International Facet Theory Conference* (pp. 166-175). Prague, Czech Republic.

Hart, R.P., Martelli, M.F., & Zasler, N.D. (2000). Chronic pain and neuropsychological functioning. *Neuropsychology Review*, *10*, 131-149.

Hart, R.P., Wade, J.B., & Martelli, M.F. (2003). Cognitive impairment in patients with chronic pain: the significance of stress. *Current pain and headache reports*, *7*, 116-126.

Hautzinger, M., & Bailer, M. (1993). *Allgemeine Depressionsskala*. Manual [General Depression Scale]. Weinheim: Beltz.

Laux, L., Glanzmann, P., Schaffner, P., & Spielberger, C.D. (1981). *Das State-Trait-Angstinventar. Theoretische Grundlagen und Handanweisung* [State-Trait-Anxiety-Inventory. Theoretical basics and users manual]. Weinheim: Beltz Test.

Millsap, R.E., Zalkind, S.S., & Xenos, T. (1990). Quick-reference tables to determine the significance of the difference between two correlation coefficients from two independent samples. *Educational and psychological measurement*, *50*, 297-307.

Pincus, T., Fraser, L., & Pearce, S. (1998). Do chronic pain patients ‘stroop` on pain stimuli?. *British Journal of clinical psychology*, *37*, 49-58.

Pincus, T., & Morley, S. (2001). Cognitive-processing bias in chronic pain: a review and integration. *Psychological Bulletin*, *127*, 599-617.

Roelofs, J., Crombez, G., Peters, M.L., Verschuere, B., & Vlaeyen, J.W. (2005). An examination of word relevance in a modified Stroop task in patients with chronic low back pain. *Perceptual and Motor Skills*, *100*, 955-963.

Sanders, A.F. (1983). Toward a model of stress and human performance. *Acta Psychologica*, *53*, 61-97.

Van Breukelen, G.J.P. (1989). Concentration, speed and precision in simple mental tasks. In E.E.C.I. Roskam & R. Suck (Eds.), *Progress in Mathematical Psychology* (Vol. 1, pp. 175-193). Amsterdam: Elsevier.

Westhoff, K. (1995). Aufmerksamkeit und Konzentration [Attention and Concentration]. In M. Amelang (Eds.), *Verhaltens- und Leistungsunterschiede. Band 2 des Bereichs Differentielle Psychologie und Persönlichkeitsforschung der Enzyklopädie der Psychologie* (pp. 375-402). Göttingen: Hogrefe.

Westhoff K. (2005). *Komplexer Konzentrationstest* (Version 21.00) [Computer Software]. [Complex Concentration Test (Version 21.00) [Computer Software]]. Mödling: Dr. G. Schuhfried GmbH.

Westhoff, K., & Hagemeister, C. (1991). Konzentrationsfehler als Prädiktoren beruflicher Leistung [Concentration Errors as Predictor of Job Performance]. In H. Schuler & U. Funke (Eds.), *Eignungsdiagnostik in Forschung und Praxis* [Assessment of Occupational Aptitude in Research and Practice] (pp. 231-234). Stuttgart: Verlag für Angewandte Psychologie.

Westhoff, K., & Hagemeister, C. (1992). Reliabilität von Fehlern in Konzentrationstests [Reliability of Errors in Concentration Tests]. *Diagnostica, 38*, 116-129.

Westhoff, K., & Hagemeister, C. (2005). *Konzentrationsdiagnostik* [Concentration Assessment]. Lengerich: Pabst.

Westhoff, K., Hagemeister, C. & Strobel, A. (2007). Decision-aiding in the process of psychological assessment. *Psychology Science*, *49*, 271-385.

Westhoff, K., & Scholz, A. (2007). *Komplexer Konzentrationstest Version 21.00. Handanweisung* [Complex Concentration Test Version 21.00. Users manual]. Mödling: Dr. G. Schuhfried GmbH.