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The effects of warnings and an educational brochure on computer working posture: a test of the C-HIP model in the context of RSI-relevant behaviour

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This study tested whether warnings can result in a better working posture with respect to RSI prevention compared with an educational brochure. By using a warning, the information provision on how to prevent RSI can be shorter and only interrupts with the task at hand for a short time. Five conditions were created to compare the effects on position adjustments of a warning displayed on the computer screen, a warning hanging on the wall, an educational brochure, a neutral interruption on the computer screen, and no intervention. Systematic observations of respondents' working postures showed that the computer warning led to significantly more correct position adjustments than the educational brochure and the two control situations, whereas the wall warning condition did not differ significantly from all other conditions. Questionnaires were used to study whether the number of position adjustments in the conditions could be explained by Wogalter's communication-human information processing (C-HIP) model. The questionnaire data suggest that the effect of the computer warning is caused by heightened attention for this type of intervention. The other stages of the C-HIP model—knowledge, attitude change, and motivation—might not be necessary in this situation in the explanation of behavioural changes. The conclusion is that warnings may be able to successfully replace educational brochures to produce behavioural changes.

1. Introduction

Repetitive Strain Injury (RSI) constitutes a considerable hazard for Visual Display Unit (VDU) workers and their employers. For example, in the Netherlands, the percentage of VDU workers suffering from RSI ranges between 19% and 56% (Blatter and Bongers 1999, Blatter *et al.* 2000, Massaar, 1998), and the costs associated with it are high for both employer and employee (Hochanadel 1995, European Agency for Safety and Health at Work 1997).

In the case of computer-based work, the injuries related to RSI are produced by a working posture that is uncomfortable and puts strain on the spine, shoulders, neck,

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arms, or wrists (Simmons and Lloyd 1995, Blatter and Bongers 1999, Health Council of the Netherlands 2000). Several improvements have been suggested in order to prevent RSI, such as an adequate screen position, making fewer than 10 000 keystrokes per hour, using little keystroke force on the keyboard, and adjustable office chairs and desks. Furthermore, the work situation might be improved by allowing employees to take short breaks every hour or by creating a pleasant work atmosphere (Simmons and Lloyd 1995).

Educational brochures containing information about the dangers of repetitive movements are often used to educate employees about RSI. However, because these brochures are not always present during computer work, the information might be easily forgotten, if they are read at all (Slater 1999). Another method to bring about 'on the spot' position adjustments might be the use of warnings, as used, for example, to warn people to stay away from high voltage areas. In the case of RSI prevention, a warning on the computer screen can let the user know if he or she is at risk and provide information about what to do to prevent further negative consequences (e.g., take a break, sit up straight). The advantages of warnings over other educational or instructional materials are that they can be provided more directly, have a brief but clear content, and attract more attention, especially when they interrupt the person's work (Wogalter *et al*. 1987, Frantz and Rhoades 1993, Wogalter 1999).

As far as the authors know, the effects of warnings compared with educational brochures in bringing about position adjustments in order to prevent RSI have not yet been studied, although they are being used in software programmes. Therefore, this study examined whether a warning could lead to more position adjustments than a traditional educational brochure. It was expected that a warning would lead to more working posture changes than an educational brochure or no intervention at all. Furthermore, an attempt was made to identify psychological variables (e.g., attention paid to the message and attitude changes after seeing the message) that may contribute to the desired position adjustments.

1.1. *Effects of previous intervention campaigns*

The few intervention campaigns to prevent RSI that have been implemented and evaluated so far seem to show subjective and objective decreases in RSI symptoms (Kukkonen *et al*. 1983, Koskela 1985, Luopajärvi 1987, Rizzo *et al*. 1997). In the study by Kukkonen *et al*. (1983), for example, computer users attended a number of lectures about basic ergonomics and received personal suggestions for improvements of their workstation. The measurements before and after the intervention, with an interval of 6 months, indicated that this intervention decreased the prevalence of RSI among employees from 54% to 16%. For the control group, which did not follow this course, there was no significant difference in prevalence between the measurements before (43%) and after (45%) the intervention.

Miedema *et al*. (1996) and the Health Council of the Netherlands (2000) concluded, on the basis of a review of available studies, that active interventions such as that implemented by Kukkonen *et al*. (1983) can decrease RSI-symptoms, whereas passive interventions, such as self-education interventions, do not prevent RSI but only help in signalling the problem in those people who are already at risk of RSI and therefore have heightened perceptions of personal relevance. Two studies that used written educational material (instruction guides and information booklets about RSI) found positive effects of educational interventions (Rizzo *et al*. 1997, Marcoux *et al*. 2000). Unfortunately, in the study by Marcoux *et al*. (2000) only the acquired knowledge of the participants was measured, not their position adjustments. Rizzo *et al*. (1997) did report on position adjustments, and participants in the intervention group showed more improvements in their working posture than the control group. However, the extent to which position adjustments came about as a result of the written information was not clear, as these participants also saw a video and attended a seminar on RSI prevention. Furthermore, the participants knew about the purpose of the study, which might have led to a more careful review of the materials than the participants would have done in more realistic settings. In short, the specific effects of an educational brochure about RSI aiming to actively promote position adjustments have not been examined yet.

1.2. *Warnings to prevent RSI*

A warning is defined as an information provision device concerning the possible negative consequence of a certain action or a lack of action (cf. Ayres *et al*. 1989). For example, cleaning personnel in public buildings use warning signs to tell people that the floor is still wet and that avoiding the area can prevent falling. An effective warning contains a signal word, a hazard statement, the consequences of not adhering to the warning, and instructions to prevent these consequences (Wogalter *et al*. 1987). These four elements can be extended or replaced by a picture or symbol, and can have different font types and sizes, and colours (Lerner and Collins 1980, Braun and Silver 1995).

Due to the compact nature of a warning, it can be positioned on or close to the dangerous product (e.g., on the wall behind the computer). The relationship between warning and product is then clear by its position (Frantz and Rhoades 1993). A warning can increase risk perception (Wogalter *et al*. 1999b) and can also prevent the execution of a hazardous action through intrusive placement (such as a warning that appears on the computer screen as soon as the user exceeds a certain working time limit). The obstruction then forces the user to at least notice the warning, which may cause more compliance as it attracts more attention (Wogalter *et al*. 1987, Frantz and Rhoades 1993). Furthermore, a message of a single word or a few words is read more often than longer messages (Wogalter *et al*. 1987).

A warning to increase user awareness of carpal tunnel syndrome, a condition in which a nerve in the wrist is compressed by swelling tendons in the carpal tunnel, was designed by Freeman *et al*. (2001). The warning design was based on the results of a questionnaire study; which indicated that the respondents valued information about the symptoms of carpal tunnel syndrome highly. However, as the effects of the warning have not been tested on behavioural changes to prevent carpal tunnel syndrome, it is unclear whether this type of warning is effective to prevent carpal tunnel syndrome.

Computer warnings already exist as software monitoring tools for RSI prevention (Thé and de Looze 2001, Kemp *et al*. 2002). Available programmes differ in the amount of information provided. Some programmes simply indicate when to take a break and for how long, and others also provide information tailored to the individual about the intensity of typing and mouse use, and suggest exercises during breaks (Thé and de Looze 2001). Although Kemp *et al*. (2002) performed a study on the usability of RSI-software and concluded that the different types of software were easy to use and that individuals should choose the software that meets their needs best, no research to date—to the best of the authors' knowledge—has been published that examined the effectiveness of these software programmes on correct computer working posture.

The communication-human information processing model (C-HIP) describes the route from attending to a warning to complying with it by performing a certain behaviour (Wogalter 1999, Wogalter *et al.* 1999a). It is firstly assumed that source, channel, and receiver characteristics should be carefully considered when designing warnings (cf. McGuire 1985). Derived from information-processing theories, the C-HIP model then suggests that the receiver moves through several stages before adhering to the warning. First, the warning attracts and holds the attention of the receiver of the message. This is followed by a stage of understanding of the warning and gaining knowledge about its content. In the next stage, the attitudes and beliefs of the receiver need to be favourable for the desired behaviour, or otherwise changed into the desired behaviour. After this, the receiver needs to be motivated to carry out the desired type of behaviour. If these stages are all fulfilled, it is very likely that the receiver will perform the desired action (e.g., sit up straight). If an individual already has some knowledge about the hazard and the warning, not all of the stages of the C-HIP model are needed in order to bring about the desired behaviour. It appears that the C-HIP model has not yet been examined in a practical situation to evaluate the effectiveness of a warning. The stages of the C-HIP model were measured in this study to explain the possible differences in effectiveness between the warning conditions and the educational brochure condition.

1.3. *Hypotheses*

In the present study, it was first predicted that warnings would be more effective in inducing position adjustments that prevent RSI related problems than a common practice educational brochure or no intervention at all (*hypothesis 1*). Secondly, it was predicted that hypothesis 1 would be especially true for warnings that interrupt the computer work as compared to those that do not interrupt the work and are continuously present (*hypothesis 2*). Finally, based on Wogalter *et al.*'s (1999a) C-HIP model, it was predicted that the advantages of the warning message over the educational brochure, as regards effects, can be explained by the ability of a warning message to attract attention better and transfer more knowledge about RSI, which is followed by more positive attitudes and motivation towards actions that may prevent RSI (*hypothesis 3*).

2. Methodology

The study took place in the behaviour laboratory of the Faculty of Psychology at Universiteit Maastricht. Eight participants could be accommodated at a time. Participants either received no intervention, an interrupting neutral image instead of an intervention, an educational brochure, a wall warning or a computer warning. Participants were observed by means of a camera to see whether they adjusted their working postures while carrying out a computer-based task.

2.1. *Participants and design*

In exchange for course credits, 125 first-year undergraduate students agreed to participate in a study that was described as an evaluation study of an ergonomically adapted keyboard. The mean age of the respondents was 19.48 years ($SD = 2.01$); 25 participants were male and 100 were female. Participants were randomly assigned to the five conditions of a one-factorial between-subjects design: two warning conditions, one educational brochure condition, and two control conditions. In the first warning condition, the warning (see Materials) interrupted the computer task every 15 min. In the second warning condition, the same warning was used as in the computer condition, but this time hanging on the wall, above the computer screen. In the third condition, respondents received an educational brochure (see Materials) before starting the computer task. In the first control condition, no RSI information was provided and no interruptions took place. In the second control condition, no RSI information was provided but the computer task was interrupted by a neutral image every 15 min, to examine whether only a change of the computer image causes position adjustments.

2.2. *Procedure*

Before the respondents took their seats in separate cubicles that were equipped with a chair, table, and computer, the purpose of the experiment was explained to them. Participants were told that they would test ergonomic and standard keyboards on their usability. They were then informed that they would be assigned to the control condition, which meant they would be testing the standard keyboard. In reality, there was no experimental condition with an ergonomic keyboard. After this, the different tasks were explained to the participants. First, they would be typing arbitrary rows of numbers, letters, and again numbers. Participants were explicitly asked to try to make as few errors as possible. In the light of the supposed goal of the study—the evaluation of an ergonomic keyboard—participants were also made to believe that during the experiment the key-strike force, typing velocity and number of errors would be recorded. Lastly, to promote the taking of breaks, the participants were told that the experiment would take at least an hour.

Next, respondents completed an informed consent form for participation in the experiment, which would be recorded on videotape. Then the researcher told the participants that the university had a new policy in which employees and respondents needed to be warned about the possible risk of RSI while working for more than 1 h at a computer. Therefore, participants in the educational brochure condition were asked to read the brochure they were given before starting the experiment. The participants in the wall warning condition were asked to take good notice of the warning above the computer. In the computer warning condition, participants were told that a warning would appear on the computer screen. The participants in the control conditions were not informed about the university's new RSI policy. After completing the computer task, which took 42 min to complete, participants were asked to fill in a questionnaire (see Measurements). Before respondents left the laboratory, the true purpose of the experiment was explained to them and they were asked not to convey any of this to other first-year undergraduates. Finally, they were thanked for participating.

2.3. *Materials*

The following materials were used: a warning, an educational brochure, a data-input program, computers, desks and chairs, and video recording equipment. The warnings were designed according to the results of several studies that examined the most effective warning (Wogalter *et al.* 1987, 1999b, Young and Wogalter 1988, Wogalter and Silver 1990, Frantz and Rhoades 1993, Silver and Braun 1993, Braun and Silver 1995, Wogalter 1999). The text of the warning consisted of the signal word 'Caution!', and a hazard statement which stated that the working posture could be incorrect, which could consequently lead to RSI symptoms (see figure 1). The instructions were explicit, suggesting that the working posture be adjusted in accordance with the picture by sitting up straight, letting the feet touch the floor, and turning the back support slightly forwards. Lastly, participants were encouraged to take a break every 15 min and also to do two types of exercises during the break. The other position adjustments should be derived from the picture in the warning.

The warning was conspicuous by its red border and white centre, and thus resembled traffic warning signs. In the computer warning condition, the warning could only be removed after 12 s by clicking on a button. This was to encourage the respondents to read the warning. The computer warning appeared on the screen every 15 min and was thus shown twice during the computer task.

In the educational brochure condition, a brochure was used that was developed by the Universiteit Maastricht for its employees, called 'Met het oog op beeldschermwerk' ('Keeping an eye on VDU work'). The text content and illustration of the educational brochure were similar to the content and illustration of the warning. The warning and brochure differed in that the educational brochure was extended in its content and also contained information about the symptoms of RSI, the development of RSI, and the rights of employees.

In the data-input programme, participants typed rows of digits and letters displayed by the computer programme. The length of the rows increased every three and a half minutes. For the numbers, the key-use changed halfway from the row of digits above the letters to the numerical keys. The computer task increased in difficulty to make the task appear to be a realistic test of the keyboard. Furthermore, the longer number and letter strings were intended to increase stress to type them correctly. The accompanying time pressure was meant to cause a situation in which one would not necessarily follow the instructions of the intervention automatically, without considering the consequences of this.

The workstation used by the participants was similar to an ordinary workstation. The computer screen was positioned on the table. The table was not adjustable in height in contrast to the office chair, of which the height was adjustable, while the back support could be adjusted in height and depth. All participants started in the

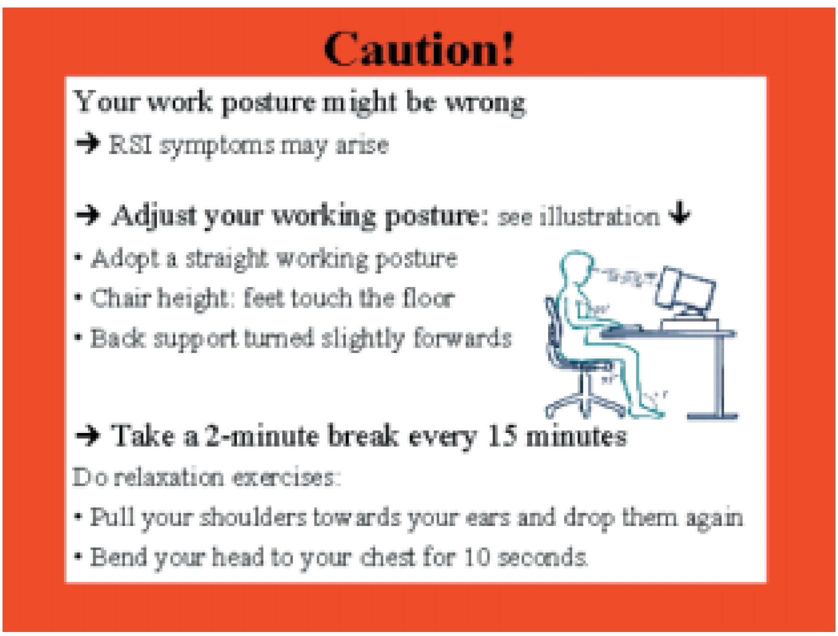

Figure 1. Warning used as computer and wall warning.

same position. The office chair was in its lowest position and the keyboard flat on the table against the computer screen. This position would be uncomfortable for all participants, so the starting situation could not result in a comfortable working posture. The behaviour of the participants was recorded on videotape. The camera was positioned in the top corner of the room behind the participants.

2.4. *Measurements*

The various position adjustments that the participants could perform before and during the computer task were recorded on videotape and later scored by the first author. The scored categories were: sitting in a straight working posture, horizontal and vertical adjustment of the back support, adjusting the chair height, putting their feet on the floor so that there was a right angle between the upper leg and the lower leg, pulling the office chair closer to the desk, moving the keyboard to the desk edge, not leaning the wrists on the desk, and changing the screen angle. Furthermore, it was observed whether participants took a break and did the exercises.

By means of a questionnaire, attention paid to the intervention (i.e., conspicuousness), knowledge about RSI, and attitude and motivation towards the recommendations were measured by five questions using 7-point Likert scales (higher scores indicated higher levels of the variables measured) and one open-ended question to measure knowledge. Conspicuousness, attitude and motivation were measured in the warning and brochure conditions, whereas knowledge was measured both in these conditions and in the neutral interference condition to find out whether the intervention would cause an increase in knowledge compared to the neutral interference condition. Conspicuousness was measured by one item asking participants whether they thought the warning or educational brochure caught their attention (1 = not at all, 7 = very much). Knowledge was measured by asking the participants to write down everything they could remember about RSI. Each correct item mentioned was counted in the total score.

Two items measured attitude towards the importance of a good working position ('Did the warning change your opinion about a good posture when working?'; 1 = not at all, 7 = very much), which were combined in one reliable index ($r = 0.82, p < 0.001$). The fifth question asked participants whether their motivation to change their working posture had been increased by this intervention (1 = not at all, 7 = very much).

3. Results

3.1. *Correlations*

Two independent observers each scored 10 participants of every condition each to check the observations of the first author. Between the three observers, reliability coefficients were analysed for the specific position adjustments. The behaviour categories putting feet on the floor, adjusting the back support in vertical and horizontal directions, changing the angle of the screen, and not leaning the wrists on the desk were not observed, and were thus not included in the following analyses. The observations that were included were those of adjusting the working posture, pulling the chair into the desk, adjusting the chair height, pulling the keyboard to the table edge, taking a break, and doing exercises. Except in the case of taking a break, the reliabilities between the observers on these specific position adjustments were high according to Cohen's kappa, κ's > 0.658, p's < 0.001. Taking a break was still significantly reliable between observer 1 and 2, and between observer 1 and 3, $\kappa = 0.370, p < 0.01$ and $\kappa = 0.485, p < 0.001$, respectively. The first author observed all participants on the video recordings; her results were used in all further analyses. The correlations between the variables studied in this experiment are shown in table 1.

3.2. *Total number of position adjustments*

A one-way analysis of variance (ANOVA) was conducted on the total number of position adjustments. Condition was found to have an effect on the total number of position adjustments, $F(4, 120) = 7.58$, $p < 0.001$. Bonferroni *post-hoc* comparisons revealed, partly in support of hypothesis 1, that participants in the computer warning condition carried out more position improvements than participants in the educational brochure condition and the control conditions. The mean numbers of position adjustments for each condition are presented in table 2. The wall warning condition did not differ significantly from the computer warning condition, which did not correspond with hypothesis 2 (see table 2); neither did the wall warning condition differ significantly from the control conditions and educational brochure condition.

To control for the fact that some respondents carried out the same position adjustments more than once, these data were changed into single adjustments. Performing a certain position adjustment several times is not better than making this adjustment only once. The former can imply that after the adjustment is made, the respondents lapse back into an incorrect position and adjust their position again later. The latter can imply that after altering the position once, the respondent is in the correct position for the remaining time. By means of a one-way ANOVA, again an effect of condition on position adjustments was found for single adjustments, $F(4, 120) = 6.10$, $p < 0.001$. Bonferroni *post-hoc* tests showed that participants in the computer warning condition carried out more position improvements than participants in the educational brochure condition, the neutral interference condition, and the control condition. The wall warning condition brought about significantly more position adjustments than the neutral interference condition but was not significantly different from the other three conditions. The mean numbers of position adjustments for each condition for single adjustments are presented in table 2.

3.3. *Specific position adjustments*

The following analyses were conducted to discover whether condition had an effect on the specific position adjustments. A multivariate analysis of variance (MANOVA) was carried out with condition as the independent variable and the six categories of position adjustments as dependent variables. In line with the analyses of the total number of position adjustments a multivariate effect of condition was found, $F(24, 402) = 3.54$, $p < 0.001$. Univariate analyses first revealed that condition had an effect on the number of position improvements in a straight working posture, $F(4, 120) = 15.74$, $p < 0.001$, and in pulling the chair into the desk, $F(4,120) = 5.30$, $p < 0.01$. The Bonferroni *post-hoc* test revealed that in the computer warning condition, more position improvements were made in the working posture, and that the chair was pulled into the desk more often than in the other four conditions (see table 3 for mean scores). A marginal significant trend was found for taking a break, $F(4, 120) = 2.29$, $p = 0.06$. The Bonferroni *post-hoc* test only showed a marginal significant difference between the wall warning condition and the educational brochure condition for taking a break, $p = 0.06$. No significant differences between the conditions were found regarding adjusting the chair height, $F(4, 120) = 1.40$, $p = 0.24$, pulling the keyboard to the edge of the table, $F(4, 120) = 1.03$, $p = 0.37$, and doing exercises, $F(4, 120) = 2,18$, $p = 0.08$ (see table 3).

Table 1. Correlations between all variables examined

		Position adjustments	Conspicuousness	Text understand	Illustration understand	Knowledge	Attitude change	Motivation	Condition
Position adjustments	Correlation	1							
	N	125							
Conspicuousness	Correlation	0.247*	1						
	N	75	75						
Text understanding	Correlation	0.227*	0.355**	1					
	N	75	75	75					
Illustration understanding	Correlation	0.321*	0.156	0.377**	1				
	N	75	75	75	75				
Knowledge	Correlation	0.148	0.175	0.105	−0.027	1			
	N	100	75	75	75	100			
Attitude change	Correlation	0.076	0.275*	0.294*	0.073	0.010	1		
	N	75	75	75	75	75	75		
Motivation	Correlation	0.228*	0.309**	0.364**	0.234*	0.001	0.742**	1	
	N	75	75	75	75	75	75	75	
Condition	Correlation	0.371*	0.401**	0.166	0.127	0.257**	0.058	0.197	1
	N	125	75	75	75	100	75	100	125

**$p < 0.01$, two-tailed. *$p < 0.05$, two-tailed.

Table 2. Mean number of position adjustments and mean number of single position adjustments in each condition, including significance, and standard deviations between brackets

Condition	Position adjustments	Single position adjustments
Control	1.28^{a} (0.94)	$1.28^{a,c}$ (0.94)
Neutral interference	0.88^{a} (0.97)	0.80^{a} (0.91)
Educational brochure	1.16^{a} (0.90)	$1.08^{a,c}$ (0.81)
Wall warning	$1.76^{a,b}$ (1.56)	$1.64^{b,c}$ (1.44)
Computer warning	2.48^{b} (1.19)	2.12^{b} (0.97)

Within-column means with different superscripts differ significantly from each other ($p < 0.05$).

Again, a correction was carried out on the data to control for the reoccurrence of specific position adjustments by the same respondent. Separate chi-square analyses were used for each specific position adjustment. A condition effect was found for a straight working posture, $\chi^2 = 42.62$, $p < 0.001$. Subsequently, the chi-square test was limited for the wall warning and computer warning conditions because the smallest difference in the mean number of respondents sitting up straight between the computer warning and the other conditions was found here. This difference was significant, $\chi^2 = 9.74$, $p < 0.05$. In the computer warning condition, more participants sat up straight than in the other four conditions. The other conditions did not differ significantly from each other with respect to the number of respondents sitting up straight (all p's > 0.05).

Also, for pulling the chair into the desk, a significant condition effect was found, $\chi^2 = 10.14$, $p < 0.05$. The following limited chi-square test was between the control condition and computer warning condition because the smallest difference between the computer warning condition and the other conditions was found here. This revealed no significant difference, $\chi^2 = 2.89$, $p = 0.09$. The same analysis between the educational brochure and computer warning condition (i.e. the second smallest difference between the computer warning condition and the other conditions) showed significant results, $\chi^2 = 5.20$, $p < 0.05$. The computer warning caused more participants to move their chair into the desk than the educational brochure. The computer warning condition also resulted in more participants moving their chair into the desk than in the neutral interference and wall warning conditions, because in the latter conditions even lower mean numbers of respondents carried out the adjustment. The other conditions did not differ significantly from each other with respect to pulling the chair into the desk (all p's > 0.05). Furthermore the other specific position adjustments also showed no significant condition effect after correction, χ^2's < 8.86, p's > 0.07.

3.4. *C-HIP model*

The stages of the C-HIP model were analysed to find out whether improvements in attention, knowledge, attitude and/or motivation led to more position adjustments in the computer warning condition than in the wall warning, educational brochure and control conditions (hypothesis 3). Therefore, a MANOVA tested the effect of condition on conspicuousness, knowledge, attitude change and motivation among participants in the warning and brochure conditions. Multivariately, the stages of the C-HIP model differed significantly between conditions, $F(8, 138) = 4.68$, $p < 0.001$. Nevertheless, univariate analyses revealed that conspicuousness was the only variable that was significantly different between the conditions, $F(2, 72) = 18.43$, $p < 0.001$ (see table 4).

Table 3. Mean number of specific behaviour changes in each condition, including significance, and standard deviation in parentheses

Condition	Straight position	Chair height adjusted	Chair to desk	Keyboard moved to table edge	Taking a break	Exercises
Control	0.16^{a} (0.37)	0.20 (0.41)	0.36^{a} (0.49)	0.52 (0.59)	0.04 (0.20)	0.04 (0.20)
Neutral interference	0.00^{a} (0.00)	0.16 (0.37)	0.16^{a} (0.37)	0.36 (0.49)	0.08 (0.28)	0.00 (0.00)
Educational brochure	0.04^{a} (0.20)	0.24 (0.44)	0.32^{a} (0.56)	0.52 (0.51)	0.00 (0.00)	0.00 (0.00)
Wall warning	0.24^{a} (0.44)	0.40 (0.50)	0.24^{a} (0.44)	0.40 (0.58)	0.20 (0.41)	0.16 (0.37)
Computer warning	0.72^{b} (0.54)	0.16 (0.37)	0.80^{b} (0.76)	0.64 (0.57)	0.04 (0.20)	0.08 (0.28)

Within-column means with different superscripts differ significantly from each other ($p < 0.05$).

Table 4. Mean scores on questionnaire items in each condition, standard deviations in parentheses

Condition	Conspicuousness	Text understanding	Illustration understanding	Knowledge	Attitude change	Motivation
Educational brochure	4.08^{a} (1.53)	4.88 (1.01)	5.08 (0.95)	2.16 (1.60)	3.60 (1.38)	3.84 (1.46)
Wall warning	3.36^{a} (1.55)	5.56 (1.42)	4.92 (1.58)	2.48 (1.58)	2.96 (1.39)	3.64 (1.85)
Computer warning	5.84^{b} (1.38)	5.40 (1.35)	5.48 (1.26)	2.64 (1.66)	3.82 (1.81)	4.68 (1.82)

Within-column means with different superscripts differ significantly from each other ($p < 0.05$).

A Bonferroni *post-hoc* test on conspicuousness showed that the computer warning was judged as being more conspicuous than the wall warning and educational brochure. No significant effects of condition were found on knowledge, attitude and motivation. However, when the neutral interference condition was included in a one-way ANOVA with knowledge, a marginally significant trend was visible, $F(3, 96) = 2.50$, $p = 0.06$.

4. Discussion

The computer warning resulted in more position adjustments than the educational brochure and control conditions during the computer task, thus partly supporting hypothesis 1. The wall warning was in-between educational brochure and control conditions, and the computer warning concerning the number of position adjustments. The wall warning did not cause significantly fewer position adjustments than the computer warning, nor did it cause significantly more position adjustments than the educational brochure or no intervention.

Hypothesis 3, that higher scores on the variables of the C-HIP model would explain the differences in number of position adjustments between the computer warning on the one hand, and the wall warning and educational brochure on the other hand, was only partly supported by the results. Only attention (in the form of conspicuousness) was higher in the computer warning condition, thus providing no support for increases in the other variables suggested by the C-HIP model (knowledge, attitude and beliefs, and motivation).

In line with hypothesis 2, interruption of the work at hand seems to be of important value in inducing position adjustments, provided that an informative message is given. First, this can be inferred from the finding that the computer warning was rated as more conspicuous. Second, the result that the mean number of position adjustments in the wall warning condition was in-between that in the control and educational brochure conditions, and that in the computer warning condition, implied that the addition of interruption during the computer task to the compact layout of the warning, including a signal word, a hazard statement, the consequences of not complying with the warning, and instructions to prevent these consequences, was needed to bring about significantly more position adjustments. This is also supported by the fact that the interruption condition in which work was interfered by a neutral image did not show more position adjustments than the control condition within which the work was not interfered.

The C-HIP model of Wogalter *et al.* (1999a) was not supported in its complete form by the results of this study. It is unclear why no significant differences between the conditions in the stages other than attention emerged in this study. Apparently, the educational brochure and the warnings did not differ in their effects on knowledge, attitude and beliefs, and motivation, although they differed in length and appearance. The finding that knowledge about RSI was higher in the intervention conditions than in the neutral interference condition, although not significantly, provides some evidence for the explanation that the brochure and the warnings affect knowledge irrespective of the specific content. In addition, the finding that the computer warning only caught participants' attention better conforms to the assumption of the C-HIP model that, in some situations, not all of the stages are needed for compliance with the warning. Warnings might sometimes act as reminders or cues to action of the correct behaviour (Strecher and Rosenstock 1997). The knowledge, attitudes, and motivation to do this are already available; it is just the moment of execution that is determined by the warning.

To conclude, since people do not often take the time to read a whole brochure, an interrupting warning may be a more optimal way of providing the information needed to perform the desired behaviour. In addition, the results appear to be promising for other situations in which educational information is needed in a compact form to produce behavioural changes.

4.1. *Limitations and recommendations*

The laboratory setting of the current study might not have been as realistic as a work situation. Despite the fact that respondents were under pressure to work fast and without mistakes, they still may have had more opportunity to adjust their position than in a work situation. Also, in a realistic situation, computer work might be interrupted by other tasks, such as using the telephone and walking to the printer, so that employees may feel no need to take breaks and do exercises, or they do not take the time to adjust their working posture. Thus, although the laboratory setting has the advantage of control, it may differ from real-life situations in some aspects.

To bring about more position adjustments through the use of warnings, it is advisable to explicitly describe position adjustments that are difficult to see in the illustration. For example, the position adjustment 'keyboard moved to table edge' was not clearly observable from the illustration and was also not carried out frequently.

Furthermore, tests are recommended to see whether more frequent appearance of the warning will lead to more position adjustments. Of course, one should be careful not to irritate computer users with too many interruptions. Especially frequent computer users may become irritated by repeated messages that provide redundant information and forced breaks during tasks that require concentration. As a result, the warning information may be ignored. However, in an evaluation study of RSI prevention software, computer users agreed that although the reminders to take a break and to do exercises were annoying, this type of software was perceived as useful and that in time, the computer users would adapt to the forced breaks (Kemp *et al.* 2002). Therefore, the recommendation is to study whether repeated message exposure causes irritation and decreases the attention for the message. In addition, to prevent frequent computer users from ignoring the warning information, it would be useful to examine the effect of interrupting warnings that vary in information content.

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