

The self-regulation of fatigue and associated complaints: an exploratory simulation

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Received 13 September 2001; received in revised form 20 January 2002; accepted 4 February 2002

Abstract

A computer simulation has been developed that reflects the microdynamics of dealing with fatigue and associated complaints. The theoretical base was derived from Leventhal, Nerenz and Steele's self-regulation model; the empirical base from a large-scale diary study carried out over a period of 3 weeks. The simulation results demonstrate that the process of self-regulation is non-linear. Consequently, some patient education assumptions are challenged: that individuals suffering from fatigue and associated complaints are likely to follow a similar trajectory, that interventions should not be started until after a 6 weeks delay, and that an intervention always produces the same results. These insights may be generalised to other health complaints that have no medical explanation.

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Keywords: Fatigue; Vague complaints; Patient's self-regulation; Unpredictability; Intervention

1. Introduction

Fatigue is a common complaint. Its prevalence varies from 7 to 45%, depending on how fatigue is measured and defined [1]. It is also a vague complaint, in the sense that often no medical explanation can be found for it. Self-regulation is an important perspective in understanding the management of such complaints because the sufferers have ample degrees of freedom in dealing with them, ranging from doing nothing to seeking medical care.

The purpose of this study is to explore the dynamics of the self-regulation of fatigue and associated complaints and to gain insight into its long-term consequences, particularly with respect to professional intervention. For this, computer simulation is an appropriate method, because the development of variables can be (re)produced and manipulated without real-world risks. Building a model for computer simulation requires selecting variables, and explicating the causal relationships between them by setting up equations sets. We combined existing theory with empirical knowledge as sources.

Our theoretical starting point was the self-regulation model as developed by Leventhal et al. [2]. This implies "a systems

framework which views individuals as active problem-solvers whose instrumental actions are a product of their perception, intellectual understanding, and emotional response to a health threat and the coping procedures used to regulate both the threat and the emotional responses to it ([3], p. 109)." In this model, sufferers dynamically cycle three processes: representation and assessment (of the illness and its treatment), coping, and evaluation. Through learning, their representations, assessments and coping strategies will alter.

2. Methods

Some of the variables and equations of the simulation model were determined using data from the Dutch National Health Survey of 1987. This consisted of single page, paper-and-pencil diaries kept by adult men and women over a period of 21 days, in which they had informally recorded any health complaints. In a pre-structured part, they registered their assessment of those complaints (whether or not worrisome and irritating, whether or not the cause was known) and the health-related actions they had taken. From this data set, 254 respondents were selected who had experienced fatigue or associated complaints (such as lack of concentration, sleeplessness, lack of energy, nervousness, tension,

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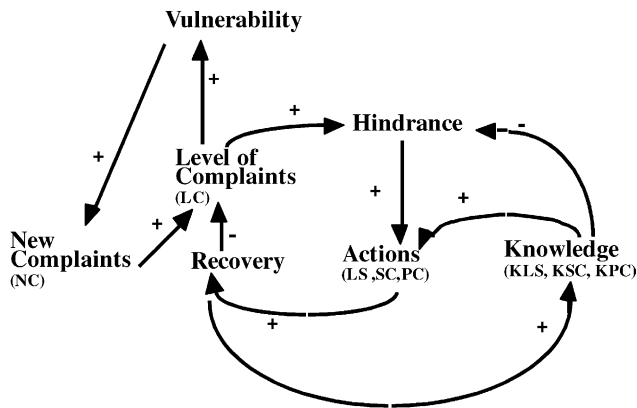


Fig. 1. A causal diagram of variables included in our model. LS: life style actions; SC: self care actions; PC: personal care actions; KLS: knowledge life style; KSC: knowledge self care; KPC: knowledge personal care.

stress and forgetfulness) for 4 days or more during the period of measurement. A preliminary analysis of this group was published in 1999 [4].

The simulation model, displayed in Fig. 1, consists of seven variables and their causal relationships. Most of the variables were observed. HINDRANCE is a combination of “feeling irritated” and “feeling concern”. ACTIONS consist of six observed variables that, according to discriminant analysis of the data, are relevant for the success of health-related actions. Together these six predicted 85% of the failures and successes. They have been clustered into three groups: lifestyle (LS), an aggregation of resting and doing exercises; selfcare (SC) comprising talking and taking home remedies; and professional care (PC) such as consulting a GP and taking prescribed medicines. Some variables were assumed, such as new complaints (NC) and RECOVERY. The last one indicates the reduction or the disappearance of complaints after applying health-related actions. KNOWLEDGE is related to the type of actions involved: lifestyle (KLS), selfcare (KSC) and professional care (KPC). LEVEL OF COMPLAINTS (LC) represents the accumulation of a number of complaints. VULNERABILITY expresses the consequences of this accumulation over a period of time.

The relationships between the variables are structured into three feedback loops: a complaints cycle, a knowledge cycle and a vulnerability cycle. The complaints cycle represents the self-management of complaints. As the LC increases, hindrance also increases, in turn increasing the level of ACTIONS. RECOVERY then leads back to lower LC. Analysis of the diary data suggests that this loop should be self-inhibiting. The knowledge cycle represents the learning of the system. RECOVERY builds up KNOWLEDGE, which both decreases the hindrance and increases ACTIONS leading to more RECOVERY. This combination of loops is assumed to be self-reinforcing, though within limits: there will be a natural ceiling at the moment when full knowledge about the management of complaints is attained. The vulnerability cycle expresses the insight that enduring complaints (LC)

increase VULNERABILITY, thus increasing the chance of NC, and heightening the LC. This loop also implies amplification.

The equations to express the causal relations between the variables are linear equations, sometimes supplemented by logical “if then” statements, and difference equations. As new complaints are assumed to arise by chance, NC was modelled as a stochastic variable. Analysis of our data set sample supplied the different weights of the six actions in actions. There is a threshold between HINDRANCE and ACTIONS which is based on the outcomes of an empirical analysis combined with the assumption that *if* an action had been successful in the past, *then* this would be learned and the chance of it being repeated would increase. Difference equations connected to the LC and the levels of knowledge (KLS, KSC, KPC) express the developments in complaints and knowledge. The essential assumption is that the LC development should be expressed in a (stochastic) non-linear difference equation [5]. (A list of equations can be obtained from the first author.)

Simulation experiments have been conducted (by using the software ITHINKTM and MADONNATM) on how the level of fatigue complaints (LC), health strategies (LS, SC, PC) and knowledge levels (KLS, KSC, KPC) develop in one individual. By running the model a hundred times, simulating 100 people, the simulation was switched to an aggregated level. Up to 365 consecutive days were modelled.

3. Results

3.1. Simulating developments in one individual

One way to judge the validity of a simulation model is to run it and analyse whether the output is logically sound. According to our experiments, a run of 50 days is adequate to observe how complaints and actions develop. With fewer days, patterns were not always fully developed while, in a longer period, no additional relevant patterns would emerge.

Fig. 2 presents a graph reflecting the output for one 50 days run. It depicts how the LC of one simulated person rises and declines and how his or her LS almost parallels the development of fatigue complaints. This output has face validity: action will be taken after a period of rising complaints and it will take some time before its effect becomes visible.

Fig. 3 exhibits how the complaints (LC) will evolve over time after introducing changes in LS and how the knowledge about the effectiveness of this health strategy (KLS) gradually increases. On day 4, an NC enters, but a health-related action on the same day has immediate success. After 14 days, the LC begins to accumulate, reaching a maximum of 6 on the day 20. LS are undertaken in the meantime, starting on day 19, and reaching a maximum of two actions a day by day 22. That causes LC to decrease, gradually, reaching 0 by

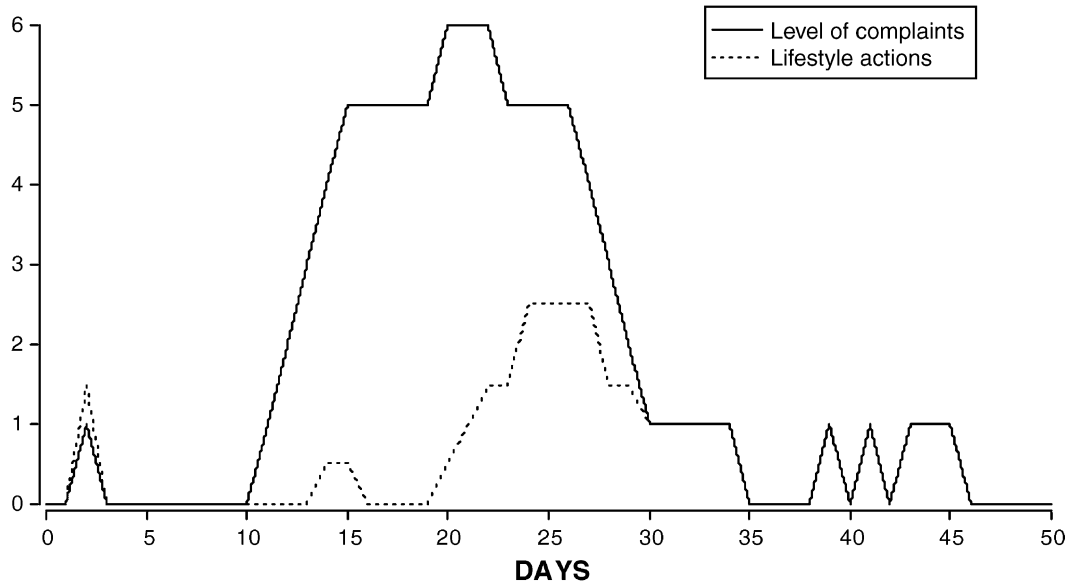


Fig. 2. Changes in the LC and LS actions of one individual during a period of 50 days.

day 35 and alternating between 0 and 1 in the days thereafter. The effectiveness of the actions is reflected in the increasing KLS.

3.2. Simulating developments of an aggregate of individuals

For experimentation at an aggregated level, we focused on the knowledge variables that are coupled to the vulnerability cycle. Being continuous in origin, KLS, KSC and KPC can show the discontinuities in the outcome patterns more

clearly than LC could have done, due to its discontinuous character.

Fig. 4 displays the result of running the model a hundred times to represent KLS developments in 100 people (for KSC and KPC similar developments were found). It shows how irregularities at the individual level take on a certain regularity at an aggregated level. In the initial stage, when KLS is still low, complaints bring about an assessment of the problem, and after a while action is taken. The learning stage starts when the subsequent recovery leads into an increase of KLS and repeated use of the actions in the following

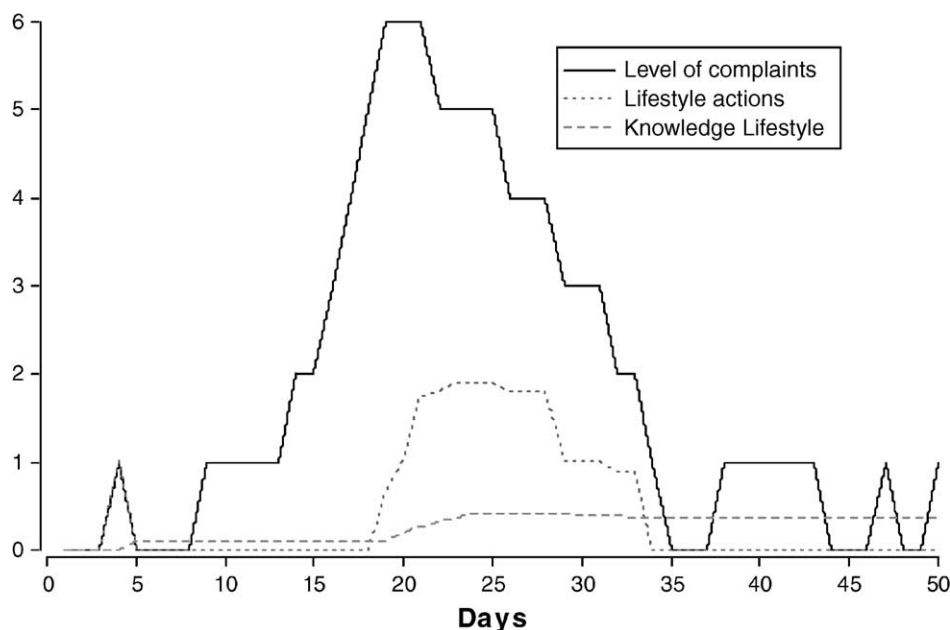


Fig. 3. The evolution over time of the LC, LS actions and KLS over 50 days.

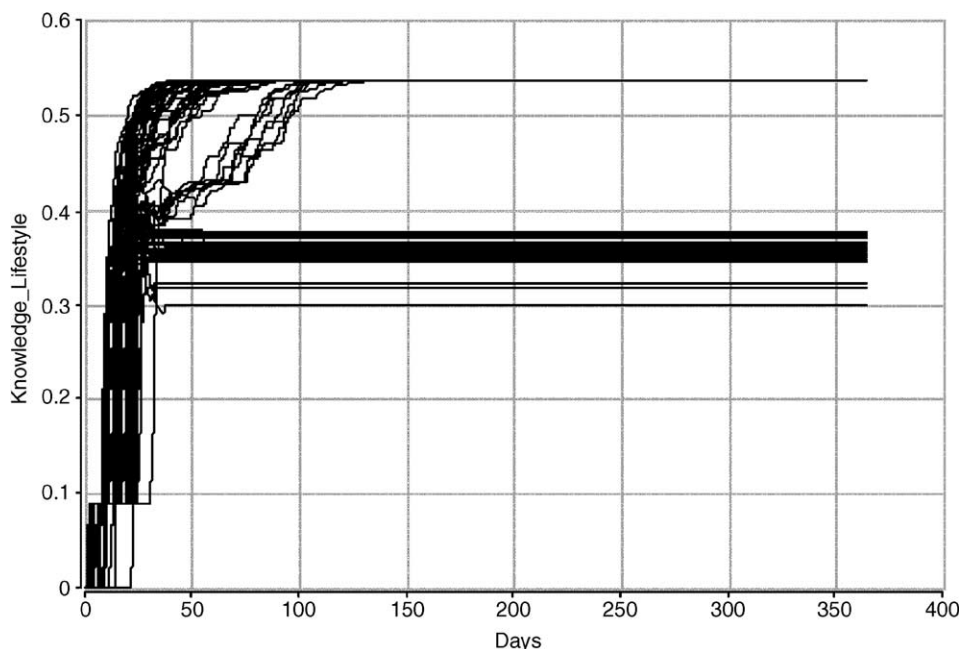


Fig. 4. The development of KLS of 100 people over a year.

episodes. During this self-amplifying process, learning is rapid (mainly within 25 days). Between the day 25 and 125, the KLS reaches its ceiling and the stage of stabilisation sets in.

The simulation pattern shows that a number of ceilings are involved (although, the aggregation of personal lines seems to form a beam in the figure). None of the levels at the end of the development were predictable. Examining the workings of the model, we found that the various final ceilings result from small initial differences, such as the order and frequency in which new complaints arise from one simulated person to the next.

4. Discussion and conclusion

Computer simulation challenges the assumption that fatigue trajectories are similar and predictable, also the (Dutch) guideline for good medical practice that GPs should take 6 weeks to wait-and-see, and the idea that similar interventions will lead to similar outcomes.

First, the learning patterns exhibited by the knowledge levels and the heterogeneity of their ceilings imply that the (externally observable) heterogeneity is produced internally. Mathematically seen, this type of outcome is not unusual, where there is non-linear behaviour in a system (here, in the vulnerability cycle), some small or random fluctuations in initial conditions can indeed result in a number of outcomes. Empirically seen, this heterogeneity of outcomes challenges the widely held assumption that the temporal pattern for most individuals suffering from fatigue is likely to follow a similar trajectory. The diversity corresponds, however, with

the finding that it is much more difficult to predict chronic than non-chronic fatigue [6].

Second, the simulation results challenge existing professional practices because the stages in Fig. 4 underline the importance of a quick start for treatment. They suggest that it is much easier to move from lower to higher levels of knowledge during the learning stage than in the stabilisation stage. This is in agreement with the finding that the fatigue-reducing effects of engaging in stimulating and pleasurable activities diminish when fatigue lasts longer [7]. Moreover, the gaps between the levels of knowledge after the onset of the stabilisation stage show that *gradual* change is impossible. One way to attain a higher KL and a more beneficial LC is for people to go back, and follow another path building up different knowledge. To achieve this, it may be necessary to stimulate them into experimenting with different types of actions or to offer new frames for assessment. Alternatively, people may be able to “jump” to a higher level by gaining sudden insight into the meaning and connection of their complaints, thus selecting new and more adequate coping actions. As the established balance of cycles has to be interrupted, a very powerful input is needed for this. This may explain the earlier finding that the success of the actions people take to improve their fatigue complaints is greater when applied simultaneously rather than sequentially [4].

Third, the rather unpredictable distribution of outcomes may explain why interventions do not always produce the same results, even if the target group, the characteristics of the intervention programme, and the context are more or less constant. This is because the levels of knowledge and complaints may become heterogeneous over time due to amplification of minor differences in the internal system.

More in general, the results invite a further exploration of patients' learning to provide more empirical evidence for health education training of professionals.

4.1. Methodological reflection

The simplifications applied in our model were either empirically grounded or deemed appropriate in this stage of the simulation project. In the future, the validity of the model may be increased by replacing some of the more simple assumptions with more sophisticated ones (for example, the possibility of autonomous recovery). Nevertheless, this would not fundamentally change the results.

Knowing that the distribution of fatigue complaints differs with gender and age [6] the model should be calibrated separately for these sub-populations. To design adequate procedures for prevention, treatment and self-management, tests should be carried out with an independent data set while simultaneously validating the simulation model, mathematically, behaviourally and structurally.

4.2. Practice implications

This article throws a new light on the difficulties that individual sufferers as well as professional interventionists encounter when attempting to manage fatigue complaints. The simulation model suggests a three-stage sequence: initial; learning; stabilisation in how complaints and the knowledge of how to handle them develop. By paying more attention to these self-regulation stages, patient educators may be able to increase their effectiveness. Early intervention, at the learning stage, is recommended. However, if the patient has already reached the stabilisation stage, a powerful (combination of) intervention(s) is necessary either to

restart the learning process or to attain a higher knowledge level. These insights might be generalised to other health complaints that have no medical explanation.

Acknowledgements

We would like to thank The Netherlands' Institute for Primary Health Care (NIVEL) for providing the data so helpfully and Prof. Jozen Bensing for offering her valuable advice.

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