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Cyberattacks: An Attempt to Obtain a Multidimensional Awareness Indicator

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Abstract: Cybersecurity is playing an increasing role in society today. Private individuals and small to medium-sized enterprises often do not have the staffing capacity to install their own information security team, including IT administrators, who could protect the enterprise against cyberattacks. A crucial step toward improving the company's defenses against cyberattacks is to increase the information security awareness of all employees. The present study focuses on a method defining a multidimensional awareness indicator applying Rasch and partial order methodology. The method is designed to suggest in a graphic form how awareness can be "sharpened" in the company through a multidimensional awareness indicator, derived from questionnaires. A two-step procedure is presented, involving the analysis of questionnaires and, subsequently, displaying an awareness indicator.

Keywords: Cybersecurity; multi-indicator systems; Rasch; partial order; awareness; questionnaire; evaluation of cyberattack categories; weightings.

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1. Introduction

Cybersecurity is of increasing importance, and companies, as well as countries, are responding to it [1]. Large enterprises or institutions usually have their IT department, and maintaining cybersecurity is one of their tasks. Seven classes of cyberattacks could be identified, challenging not only on a national level but also globally [1]. The situation is far more difficult for small enterprises or private persons, as cybersecurity relates to individual or staff capacity and is thus often not adequately performed [2]. In contrast to larger enterprises, where the information flow can be assumed to be organized hierarchically and thus work efficiently, the information sources and sinks in smaller enterprises may be associated with a variety of job profiles, such as production, process management, marketing, and others. Consequently, raising awareness and preparing for unpredictable attacks pose a challenge and require the education and training of all employees in both small and large companies.

A recent German study [3] shows that a priori any company may be susceptible to cyberattacks. Back in 2007 [4], it was assumed that the various information security (ISec) measures of the previous years had had a positive influence on the corporate cultures of numerous German organizations and the security-related behavior of employees, although the effects of these measures were not sustained. Hence, there has been no significant increase in organizational measures for ISec—including awareness raising and training for managers and employees—and only a third of the companies surveyed have an action plan for emergencies [3]. This contradiction shows a paradox in German companies, with an evident lack of sustained implementation of awareness-raising measures, especially in small and medium-sized enterprises (SMEs).

The present study is an attempt to obtain a multidimensional indicator, which can be used in the safety field to evaluate assessments in SMEs. The study is based on an exemplary case mimicking an SME with seven employees. The eventual objective of the study is to propose a multidimensional awareness indicator that may serve as a basis for evaluating the current state of knowledge and thus recommending individual training measures. The present study is a part of the ALARM project [5], which focuses on ways of raising awareness and increasing the knowledge of individuals in small enterprises on the topic of cybersecurity [6,-10]. It thus focuses on a “matching method” defining a multidimensional awareness indicator, which can be graphically displayed as a Hasse diagram using a partial order methodology. The diagram immediately indicates the major focus area for subsequent action or training, i.e., to define how awareness on an overall basis could be “sharpened” in the organization. Further, the method allows for the disclosure of individual needs for training in cybersecurity-related issues. It is shown how a multidimensional awareness indicator, derived from questionnaires, can be implemented. Hence, a two-step procedure is presented, firstly involving the analysis of questionnaires, and secondly showing an awareness indicator based on a combination of the results.

2. Material and Methods

2.1. Data

The data for the study were obtained by applying ten questionnaires developed and accessible as a web application. A group of seven respondents, here students (in the following, r denotes the number of respondents, r = 7, and L is the group of respondents), had to answer the questionnaires. If the respondent answered correctly, they were assigned a “1”; if not, a “0”. This simple rule implies that there is no difference between “not answering” and a wrong answer. Thus, each of the ten questionnaires provides a system of dichotomous responses, resulting in ten binary matrices with rows associated with the respondents and columns associated with the specific items belonging to a certain category. To preserve the respondents’ anonymity, random codes are generated and used instead of the respondents’ names.

Questionnaires

In total, 104 questions were formulated and subsequently assigned to ten categories (Table 1). The individual questions (in German) are available on demand (from the third author). In the appendix 1, the questionnaire for the Home Office (HO) section is shown as an exemplary case.

Table 1. Questions and categories.

Category (abbreviation)	**Number of questions, kq**
Home office (HO)	9
Malware (MW)	15
Emails (EM)	8
Passwords (PW)	8
Social engineering (SE)	8
Software (SW)	20
Enterprises (UN)	11
Cryptography (KR)	8
WEB (WEB)	9
Jurisdiction (RE)	8

2.2 Data Handling

The questions and categories give rise to a framework, a “level structure,” organized based on increasing complexity and ranging from level 0 to level 3.

Level structure

- Level 0: Any category j results in a binary matrix, called B(j), having r rows corresponding to the number of respondents and kq columns corresponding to kq questions within category j. Hence, an entry of B(j) is B(j,i,k) with j = 1, …, 10, if = 1,…,r and k = 1,…; the same applies to kq. B(j,i,k) allows a preliminary evaluation of the respondents based on their knowledge concerning **one** question, taken from category j. In practice, this evaluation does not play any important part as kq questions are deemed to represent the jth category.

- Level 1: Here, the complete set of questions in category j is of interest. A good evaluation of a respondent requires them to provide the correct answer for most of the kq questions. Any column of B(j) is a dichotomous answer to the questions in the specific category (note: missing answers or wrong answers are not differentiated). To facilitate later analyses, this multi-indicator system (MIS) will be denoted as "Level1_MIS". As ten categories are available, there are correspondingly ten Level1_MISs to be considered to take full account of all the knowledge about cyberattacks.

- Level 2: Level 2_MIS is an extension of Level 1 and useful as a test quantity, i.e., the rowsum RS calculated as:

  $$RS(j,i) = \sum B(j,i,k) \quad k=1,\dots,kq,\ j=1,\dots,n \qquad (1)$$

- Together with the colsum CS, the rowsum RS constitutes the initial test parameters of the item response theory (the Rasch model) [11], where RS and CS are initial indications of the responder's ability and the difficulty of the questions, respectively. Hence, in the rowsums (eq 1), it is not individual knowledge concerning the kq questions of a certain category that is measured but some "averaged" B(j). (see section 3). As there are ten categories, the ten resulting rowsums are subsequently concatenated to describe the whole questionnaire system.

- Level 3: The rowsums are no longer concatenated but combined numerically in weighted sums for the n categories:

  $$RSw(j,i): = \sum w(j)*RS(j,i) \quad k=1,\dots,kq,\ \ j=1,\dots,n \qquad (2)$$

  Symbolically, it may be useful to introduce a shorthand notation:

  $$RSw(j,i) = RS(1,i) \oplus RS(2.i) + \dots \oplus + \dots + RS(10,i) \qquad (3)$$

There is a significant difference between eq (1) and eq (2), i.e., moving from Level 2 to Level 3. However, this transformation is simply a dimension reduction: in other words, the vectorial quantity in eq. 1 is replaced by just one vector characterizing all the categories for the single respondent. A dimension reduction within an MIS always reduces the informational content, which, on the other hand, facilitates the subsequent analysis [12].

The possible drastic effect of a dimension reduction can be partially compensated for by an improved description of the role of the single categories. Thus, instead of only **one** single weighting scheme, it is possible to allow the modeling of different ideas concerning the contextual importance of each of the categories by accepting any weighting scheme that represents the respondents' opinion about the role of the ten categories.

When there is only one weighting scheme, then the result of the matrix multiplication is one vector, consisting of r rowsums multiplied by their weighting wj. This vector generates a linear or weak order.

$$(w1,w2,\ldots,w10) \quad * \quad \begin{bmatrix} RS(1,i), \\ RS(2,i), \\ \ldots \\ RS(10,i) \end{bmatrix} \qquad (4)$$

The above may easily be extended. Thus, instead of the one-dimensional row matrix (w1,w2,…,w10), a matrix G comprising ω weighting schemes (and here the ten categories) is introduced:

$$G = \begin{bmatrix} w1,1,\ w2,1,\ ..,w10,1, \\ w1,2,\ w2,2,\ \ldots,w10,2 \\ \ldots. \\ w1,\omega,\ w2,\omega,\ \ldots.,\ w10,\omega \end{bmatrix} \qquad (5)$$

Subsequently, G, now defined as a system of ω weighting schemes, can be applied to the rowsums RS(1,i), RS(2,i), etc.:

$$\begin{bmatrix} w1,1,\ w2,1,\ ..,w10,1, \\ w1,2,\ w2,2,\ \ldots,w10,2 \\ \ldots. \\ w1,\omega,\ w2,\omega,\ \ldots.,\ w10,\omega \end{bmatrix} * \begin{bmatrix} RS(1,1),\ldots,RS(1.r) \\ RS(2,1),\ldots,RS(2.r) \\ \ldots. \\ RS(10,1),\ldots.,\ RS(10,r) \end{bmatrix}$$

$$= \begin{bmatrix} \sum RSj,1*wj,1;\ \sum RSj,2*wj,1;\ \ldots \sum RSj,r*wj,1; \\ \sum RSj,1*wj,2;\ \sum RSj,2*wj,2;\ \ldots \sum RSj,r*wj,2; \\ \ldots. \\ \sum RSj,1*wj,\omega;\ \sum RSj,2*wj,\omega;\ \ldots \sum RSj,r*wj,\omega; \end{bmatrix} \qquad (6)$$

By opening the space for several weighting schemes, where the matrix G has as many rows as experts deploying different weighting schemes, ω, find appropriate, the extreme advantage of this notation becomes evident as the weighting schemes can be characterized as an important quantity independent of the subsequent algorithmic analysis. It is often useful to speak of G as a linear operator, acting on the indicators of Level2_MIS and generating Level3_MIS. Hence, the generalized eq. 6 (with more than one weighting scheme) plays a role. It associates a certain MIS with a new one (with added information), which is helpful as far as ω different weighting schemes are considered useful.

The above process, which simultaneously includes a series of weighting schemes, is called a Generalized Linear Aggregation (GLA): this has been described in detail by Carlsen and Bruggemann [13,14] in previous papers and shall not be further described here.

2.3. Partial Order

In contrast to many other multicriteria methods, partial ordering applies the original without any pretreatment such as, e.g., aggregation of indicator values. Hence, the importance of the single indicators can be immediately disclosed [12]

2.3.1. Basic Equation

The key equation to evaluate MIS-systems is eq. 7, where x, y are the objects (the respondents) and $q_j(x)$ and $q_j(y)$ the values of the jth Indicator j = 1,…,n (here n=10 corresponding to the ten questionnaires)

$$x \leq y: \Leftrightarrow q_j(x) \leq q_j(y) \text{ for all } j = 1,\ldots,n \quad (7)$$

If eq. 7 is fulfilled for x, y, then x is regarded as comparable with y; if not, it is said that x is "incomparable" with y. In partial order theory, this fact is denoted as $x \parallel y$ and always reflects a conflict, expressed by different values among at least one pair of indicators.

Eq 7 provides the analysis with the requisite flexibility, as the results can be thought of on a double bipolar axis system. A respondent here may obtain satisfactory results with a low level of information, whereas some other respondents will obtain satisfactory results with multiple pieces of information. The discrimination is the result of the number of incomparabilities, U, found for a certain partially ordered set:

$$U := |\{x \in X, y \in X, \text{ with } x \parallel y\}| \quad (8)$$

A partial order is conveniently visualized by a Hasse diagram [12,15]. Access to partial order within the context of cybersecurity is in Bruggemann et al. [1]. For the mathematical computational aspects of partially ordered sets, cf. result studies by Bruggemann and Patil [12], Bruggemann and Voigt [16], Carlsen and Bruggemann [17,18], and Carlsen [19].

2.3.2. Some Important Notions

A series of notations is important when dealing with partial ordering:

- Incomparability: i.e., Eq 7 is not fulfilled. An incomparability resulting from eq. 7 indicates a conflict in the values expressed by at least two indicators of the applied MIS.
- Maximal element: all objects for which no y exists in eq 7.
- Minimal elements: all objects y for which no object x exists fulfilling eq 7.
- If there is exactly one maximal/minimal element, then the partial order has a greatest/least element.

- Chain: a subset of mutually comparable objects
- Weak order: a set of objects where no incomparability appears, although ties are possible.
- Anti-chain: a subset of mutually incomparable objects

Partial order gives insight into the extent to which a ranking is possible taking all the indicators into account simultaneously. The tool of interest is the concept of chains because each chain allows a ranking in an MIS restricted to a subset of objects. The MIS is the basis for a partial order which focuses interest on the construction of indicators themselves [13,14,20,21] and when the partial order has enough comparabilities so that each object can be compared with the majority of other objects, then we regard this partial order as a representation of a multidimensional indicator—in this case, as a multidimensional awareness indicator.

2.3.3. Software

All partial-order analyses were conducted using the PyHasse software [22]. PyHasse is programmed using the interpreter language Python (version 2.6). Today, the software package contains around 140 more or less specialized modules. Selected modules may be obtained from the corresponding author (LC).
Some matrix operations are conducted by applying the software R.

3. Results and Discussion

Following the above outline for the level structure concept, we first turn to the basic approach, provided by the ten single questionnaires using the home office (HO, see Table 1) as an exemplary case. In Table 2, a typical binary matrix for “Home office”, j = 1, i.e., corresponding to Level 1, is shown.

Table 2. Binary matrix obtained from L and nine questions from the category Home office (HO) (questions no 70, 71, …, 169, 173).

HO	70	71	137	141	149	150	160	169	173
dc85	0	0	1	0	0	0	0	0	0
8389	1	1	1	0	1	0	0	0	0
f615	1	0	0	0	1	0	0	0	0
325	1	1	1	1	1	1	0	0	0
84ef	1	1	1	1	0	1	0	0	0
922f	1	1	1	0	0	1	0	0	0
a2de	1	1	1	1	0	0	0	0	0

It is not meaningful to discuss any single question (Level 0), as this will not give any general information about the status of the group of respondents. Level 0 can thus be ignored. This leads immediately to Level 1, which allows the respondents to be ranked according to the nine indicators (questions) found in the questionnaire HO. Here, the concept of partial order comes into play. In Fig. 1, the Hasse diagram corresponding to the MIS given in Table 2 is shown, indicating the highest level of knowledge by 325, whereas it is indicated that dc85 and f615 possess the lowest level of knowledge on cybersecurity issues related to home office (HO)

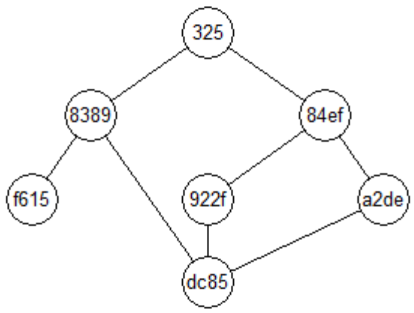

Figure 1. Hasse Diagrams. Based on the MIS in Table 2;
No. of comparabilities: 13; No. of incomparabilities, U=8.

Concerning the above description of Hasse diagrams (Fig. 1), it is immediately noted that the partial order represented by the Hasse diagram of HO has many comparabilities. Further, the diagram displays a maximal and greatest element (325), two minimal elements (f615 and dc85), an example of a chain dc85 < 922f < 84ef < 325, and an example of an antichain {f615, 922f, a2de}.

In level 1, the evaluation is based on the number of incomparabilities. A partially ordered set (poset) with a high degree of incomparabilities (number of incomparabilities, U, compared to the maximum number of binary relations) reveals a knowledge structure where "every respondent knows his 'own' questions." There is no commonality among the respondents. Conversely, a poset where the number of incomparabilities is low represents a knowledge structure where respondents know many questions in common.

Individual knowledge should be related to the background information of each respondent. However, little is known about, for example, the educational stage of respondents, their age, their gender, etc. Hence, the analysis in level 1 is necessarily restricted to reporting the incomparabilities, U, found for each category. In Table 3, the ten categories (see Table 1) are ordered according to increasing incomparability.

Table 3. Categories and incomparabilities ordered according to the number of incomparabilities, U.

Category	Incomparabilities, U	Remark
EM, SE, UN	6	Hypothesis: systematic knowledge structure
HO	8	Knowledge structure is indifferent
WEB	12	Hypothesis, no systematic knowledge structure
KR, RE	14	Hypothesis, no systematic knowledge structure
PW	15	Hypothesis, no systematic knowledge structure
MW	18	Fifteen questions. Here the noticeably enhanced number of questions leads to an enhanced number of incomparabilities.

SW	19	Twenty questions. Here the noticeably enhanced number of questions leads to an enhanced number of incomparabilities.

In general, an increasing number of items implies an increasing number of incomparabilities (see, e.g., [23]). However, an increasing number of questions does not necessarily always enhance the number of incomparabilities: even with eleven questions, as in the case of category UN, the number of incomparabilities is the same as for EM and SE with only eight questions.

As the information obtained from the single categories does not reveal an overall picture, the next step is to go to Level 2, where the Level 2 MIS is composed of the rowsums (RS) obtained from the ten individual categories (see the above HO example, Table 2). In Table 4, the Level 2 MIS comprising the rowsums is shown. However, to comply with the differences in the number of questions, it is necessary to normalize the values in Table 4 (Table 5).

Table 4. Values of RS(j;i) as the outcome of eq 1.

Cat\resp	dc85	8389	f615	325	84ef	922f	a2de
HO	1	4	2	6	5	4	4
MW	6	5	8	9	7	10	7
EM	3	4	1	4	2	3	3
PW	4	4	5	3	4	3	3
SE	0	6	0	7	7	7	4
SW	5	2	15	13	14	12	13
UN	0	6	6	10	7	6	8
KR	4	3	2	5	4	4	2
WEB	2	6	6	7	5	7	4
RE	4	3	2	5	4	4	2

Table 5. Rowsums normalized according to the number of questions in each category (cf. Table 1).

Cat\resp	dc85	8389	f615	325	84ef	922f	a2de
HO	0.111	0.444	0.222	0.667	0.556	0.444	0.444
MW	0.400	0.333	0.533	0.600	0.467	0.667	0.467
EM	0.375	0.500	0.125	0.500	0.250	0.375	0.375
PW	0.500	0.500	0.625	0.375	0.500	0.375	0.375
SE	0.000	0.750	0.000	0.875	0.875	0.875	0.500

SW	0.250	0.100	0.750	0.650	0.700	0.600	0.650
UN	0.000	0.545	0.545	0.909	0.636	0.545	0.727
KR	0.500	0.375	0.250	0.625	0.500	0.500	0.250
WEB	0.222	0.667	0.667	0.778	0.556	0.778	0.444
RE	0.500	0.375	0.250	0.625	0.500	0.500	0.250

From Table 5, each RS-indicator defines only a weak order, as there are ties. Thus, again applying the category HO as an example RS(HO): dc85 < f615 < 8389 ≅ 922f ≅ a2be < 84ef < 325, which can also be seen as a (weak) linear order corresponding to the Hasse diagram (Fig. 1).
The partial ordering based on the Level 2 MIS (Table 5) appeared to have an exceptionally low level of information (Fig. 2).

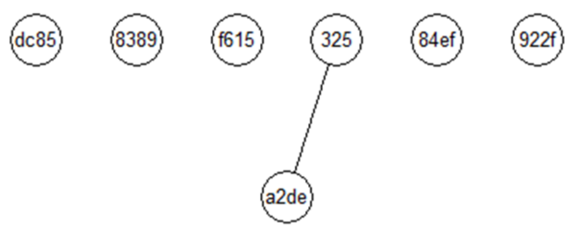

Figure 2. The Hasse diagram based on Level 2_MIS.

The Hasse diagram (Fig. 2) has a high number of incomparabilities, namely twenty, and only one comparison (325 and a2de). As 7*6/2 (=41) binary ≤ - relations among the seven respondents are possible, the degree of incomparability is 40/41 = 0.98. Consequently, Level 2 is not considered suitable for deriving a representation of an awareness indicator and calls for further methodological research.

For this purpose, weighting schemes must be formulated, which is done by groups of experts. In the following, this Level 3 approach is demonstrated by applying a group of eight experts assigning weights to the individual categories (cf. Table 1): 1: unimportant; 2: important; and 3: very important (Table 6).

As already mentioned above, the Level 3 approach is nothing other than a general linear aggregation (GLA), where "general" refers to the fact that several weighting schemes are simultaneously taken into regard [13,14]. The task of the experts is to find/define a weighting matrix G (eq. 5). In the present study, the weighting schemes for an expert group of eight individuals, al1 to al8, all being members of the research team for the project "ALARM Information Security" were applied. Thus, the experts all have a high degree of familiarity with the subject. In Table 6, the resulting G matrix is shown.

Table 6. Eight weighting models relating to the eight members of the expert group.

Exp\cat	HO	MW	EM	PW	SE	SW	UN	KR	WEB	RE
al1	2	2	2	3	3	2	2	2	3	2
al2	2	1	3	3	2	1	2	1	2	3
al3	3	3	3	3	3	2	3	2	3	2
al4	3	2	2	3	3	2	3	1	2	1
al5	3	2	3	3	2	2	2	1	3	2
al6	3	2	3	3	2	2	2	1	3	1
al7	1	1	2	1	2	3	2	2	3	2
al8	2	3	3	2	3	1	3	1	2	2

It should be noted that the evaluation of different weighting schemes needs a further algorithmic step to guarantee that the relevant quantities (eq. 7) are of the same order of amount, i.e., are mapped onto a scale [0,1]. Thus

$$\text{weight} \leftarrow (\text{weight})/(\sum \text{weights}) \quad (9)$$

The Pearson correlation between the single weighting schemes disclosed a maximal value (squared) of 0.843, found for ('al5', 'al6'), and a minimal value (squared) of 0.09, found for ('al1', 'al7'). Moreover, the pair (al1, al8) also had a very low value (0.14). In Fig. 3, the resulting partial ordering following the GLA procedure is shown, displayed as a Hasse diagram.

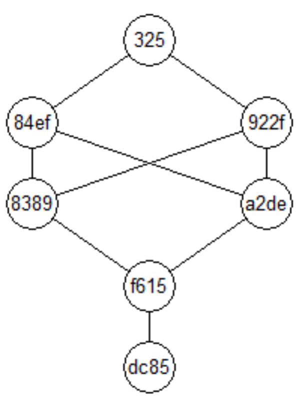

Figure 3. Hasse diagram based on the MIS (Table 5) and the G matrix in Table 6.

The Hasse diagram shown in Fig. 3 can be seen as a representation of a multidimensional awareness indicator because

- of the length of the chains,
- the fact that there is a greatest and a least element (which is an optimal result because a unique bad and a unique good element within a partial order seems to be a natural requirement), and
- the very low degree of incomparabilities (2 incomparisons and 18 comparisons)

Given the complexity of knowledge, even based on only ten questionnaires, it is acceptable that the result of an awareness indicator cannot be represented simply.

It is immediately clear (see Fig. 3) that the mutual locations of the single respondents in the diagram are only relative, i.e., although, for example, a2de is “better” (located higher) than dc85, there is no clue as to the actual knowledge of dc85 in absolute terms. To overcome this, four new artificial respondents are introduced to amend the MIS in Table 4, i.e., min., low, high, and max., describing all wrong (min.) and all correct (max.) answers and 1/3 correct (low) and 2/3 correct (high) answers, respectively (Table 7). The resulting partial ordering follows the GLA procedure.

Table 7. Artificial respondents to secure an absolute ranking.

	min.	low	high	max.
HO	0	0.333	0.667	1
MW	0	0.333	0.667	1
EM	0	0.333	0.667	1
PW	0	0.333	0.667	1
SE	0	0.333	0.667	1
SW	0	0.333	0.667	1
UN	0	0.333	0.667	1
KR	0	0.333	0.667	1
WEB	0	0.333	0.667	1
RE	0	0.333	0.667	1

The level structure of the diagram indicates the mutual ranking. However, the partial ordering methodology offers to calculate the average ranking, which, in the present case, is performed by applying the procedure reported by De Loof et al. [24] and adapted for PyHasse (the theoretical explanation can be found in [12]. Hence, the seven respondents are, together with the four artificial respondents, ranked as max > 325 = high > 84ef = 922f > 8389 = a2de > f615 > low > dc85 > min.

Although we now have a multidimensional awareness indicator as displayed in Fig. 4, the data allows us to proceed a step further. The company must find out where the shortcomings are to set up an appropriate scheme to improve knowledge levels. For this purpose, we return to the MIS given in Table 5.

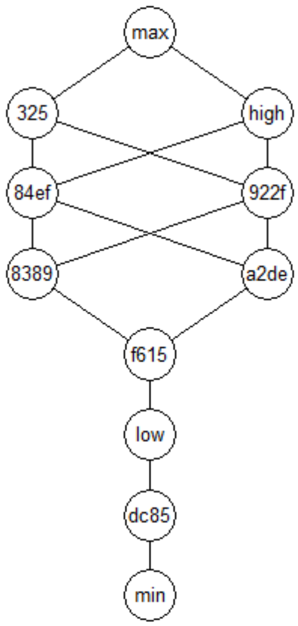

Figure 4. Hasse diagram displaying the absolute partial ordering of the seven original respondents (51 comparisons and 3 incomparisons).

The single entries in Table 5 give the fraction of correct answers for a given respondent to the questions in each category. Hence, these figures give immediate insight into where the shortcomings are for the single respondents and thus allow appropriate training schemes to be set up for the single respondents.

4. Conclusions and Outlook

Cybercrime has developed into an increasing problem in recent years. Private individuals and small and medium-sized enterprises (SMEs) are especially vulnerable to cyberattacks. There appears to be a lack of the necessary knowledge and insufficient staff resources to address the problems. The present paper describes the development of a simple multidimensional awareness indicator based on individual answers to a series of questionnaires to disclose the actual level of understanding of the problems. The relative importance of the single questionnaires has been weighted by a group of experts. The resulting indicator is displayed as a partial ordering by a Hasse diagram. The indicator makes it possible in both relative and absolute terms to reveal where the shortcomings are, and the data further allows specific areas to be identified where appropriate training should be initiated.

In the present study, a group of seven respondents to ten questionnaires was used as an exemplary case, and the relative importance of the questionnaires has been weighted by a group of eight experts. If appropriate, both the number of respondents, the number of questionnaires, as well as the number of experts can be increased (or decreased) without jeopardizing the mathematics.

Based on the questionnaire and the determined level of knowledge of an employee, an individual training plan should be developed for each employee after an evaluation. This deviates from the previous practice of training all employees in all categories without distinction, even if there is obviously no specific need. It should be noted that not all question categories are relevant for all groups of employees. Thus, it is possible to add new or exclude specific categories to make sure that the overall questionnaire fits the target group. Generally, the questions should not be too technical in order to offer all employees, regardless of their level of knowledge, an easy introduction to the topic of security.

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Appendix 1. Questionaries for the HomeOffice (HO) section

Home office

Question 1: "You work in your home office and have to leave it for a short period. What should you consider?"
Answers:
0 "I leave my workplace as it is because I can lock the door."
1 "It's only necessary to lock my PC because I'm only leaving the room for a short time."
2 "I leave everything as it is. I don't even have to lock my door because I'm only going to be away for a short time."
3 "I lock my PC, put away all open files/documents, and lock the room."
feedback "To ensure the best possible information security, you should lock the PC, put away sensitive documents, and lock the room."
category "3"
id "108"

Question 2: "Which of these email attachments should you not open?"
Answers:
0 "File with extension .jpg"
1 "File with the extension .png"
2 "File with the extension .exe"
3 "File with extension .gif"
4 "File with the extension .docx"
feedback "Executable programs (exe) should not be opened. Caution is generally advised with all types of attachments, especially with .gif and Office files, which may contain macros."
category "3"
id "110"

Question 3: "Your computer became slower over time, and you often had to wait until the program had started and you could continue working. The following offer, which you received by email, is just right for you! You optimize memory and access times by downloading and installing a program that is attached to the email as a linked file. Would you try the program?"
Answers:
0 "Yes, I use every opportunity for optimization."
1 "Yes, but I'm waiting for direct deployment as standard software."
2 "I'll look for discussion forums that deal with this question and decide later."
3 "No, I wouldn't use this option."
feedback 'Optimizations through the operating systems themselves are standard today. So it is not necessary to install “special software”. If the system still becomes slow, you should consult a computer specialist and create a backup (data backup) if the storage medium is defective.'

category "3"
id "116"

Question 4: "Your antivirus program has found a suspicious file. How do you respond?"
Answers:
0 "I'll call the IT security officer and let him or her know about it."
1 "I click away the notification because it comes every time I start."
2 "I'm downloading a new antivirus program that won't allow suspicious files onto the PC."
3 "As a technically experienced computer user, I look at the file carefully and then decide for myself."
feedback "You should notify the IT department or IT security officer, even if you suspect the file is harmless."
category "3"
id "117"

Question 5: "What often happens when an employee's computer is infected with malware?"
Answers:
0 "Spam emails can be sent on behalf of the person."
1 "This person is receiving emails from unknown senders."
2 "The person can no longer send attachments via email."
3 "The person is asked to test their PC for malware."
4 "The system is being damaged or misused to distribute malware."
feedback "Malware is malicious software (such as viruses, worms, etc.) that penetrates computer systems and can cause disruption or damage."
category "3"
id "118"

Question 6: "Which Wi-Fi encryption should you choose if possible if you use a wireless connection in your home office?"
Answers:
0 "WPA"
1 "WEP"
2 "WPA2"
feedback "WEP is an outdated standard and should no longer be used. WPA2 (or WPA2-PSK, WPA2 AES or WPA2 CCMP) should be the preferred encryption method. If it is a modern router, it may already support WPA3. Check Settings in your router (old = WPA2, new = WPA3)"
category "3"
id "180"

Question 7: "WPS enables WLAN devices to quickly establish a connection to the router, such as a network printer. Some manufacturers can use a multi-digit PIN to establish a connection to new devices. Should this setting be deactivated in the router? "

Answers:
0 “yes”
1 "no"
2 "whatever"
feedback "The keys are often very short and allow someone to break into the WLAN by trying out the keys (a so-called brute force attack)."
category "3"
id "181"

Question 8: "What should you definitely avoid when working from home to prevent data loss from a security perspective?"
Answers:
0 "Disruptions caused by roommates, e.g., the children."
1 "Working at an open window."
2 "Screen reflections on mirrors and windows."
3 "Activated voice assistants that are not needed for work."
4 "Inappropriate clothing at Online