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Psychology of Security

A Research Programme

Stefan Schumacher

IT Security is often considered to be a technical problem. However, IT Security is about decisions made by humans and should therefore be researched with psychological methods. Technical/Engineering methods are not able to solve security problems.

In this talk I will introduce the Institute's research programme about the Psychology of Security. We are going to research the psychological basics of IT security, including: How do people experience IT security? How are they motivated? How do they learn? Why do people tend to make the same mistakes again and again (Buffer Overflow, anyone?)? What can we do to prevent security incidents? Which curricula should be taught about IT security?

It is based on the 2013 talk »Psychology of Security« and also incorporates parts of my 2014 talk »Security in a Post NSA Age?« held at AUSCert Australia and »Why IT Security is fucked up and what we can do about it« held at Positive Hack Days Moscow.

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1 Security as Human Behaviour and Experience

Psychology is the science that describes and predicts human behaviour and experiences. It researches human development and it's internal and external causes and conditions. Psychology is an empirical and theoretical science with different branches like differential and personality psychology, social psychology, industrial psychology, organisational psychology and pedagogical psychology.

Besides those fundamental and applied branches, scientific psychology also consists of methodological branches. Those subjects research and teach the fundamental methodology required to do scientific research in the field of psychology. Some of those fundamentals are statistics, qualitative and quantitative research methods, the construction of questionnaires and theory and philosophy of science, among others.

If I want to discuss a Psychology of Security, I have to define or explicate what *security* means. I did so in Schumacher (2011, 2012, 2013) and developed the following definition of security:

> Security is a latent social construct and has to be treated as such. Psychological and sociological methods and tools are required. If the security of a system should be enhanced, a diagnosis, prognosis and intervention is required.

With this definition of security I extend the view to look beyond technical limitations. Computer science and information technology exclude human behaviour, since it is very complex to asses and manage. But this limits security research and security measurements to technical problems and solutions.

I prefer another view of security measures: Especially Heinz von Foerster did a lot of research about decision making as the base of human behaviour. According to his theory, human behaviour is all about decision making. The decisions themselves can be grouped into trivial and non-trivial decisions. The difference between trivial and non-trivial decisions is their measurability. Trivial decisions can be measured and made, even by algorithms. Non-trivial decisions cannot be made based on some well defined stats or by algorithms, the decisions have to be made by humans. An example for a non-trivial decision is the legal definition of marriage, which has been changed numerous times throughout history. For example during the German *Kulturkampf* in the 1870s, where the religious marriage lost it's legal value and only civil marriage became mandatory, or the current debate about homosexual marriage (cf von Foerster 1993a,b, 2008; von Foerster and Pörksen 2006).

When we reflect upon the nature of security, we can see that human decision making plays a huge and vital role in it. Not only concerning phenomena like social engineering or spear phishing, but in every decision made or discussion about security, including its very definition.

So, whenever we speak about security we speak about humans making decisions. How and what decisions are made can be influenced by standards or algorithms that define security, e.g. as in the German standards DIN EN 61508 / VDE 0803 or DIN EN ISO 13857 or ISO/IEC 27001. However, human decisions are also influenced by the biography of each individual making its decision. Even the decision to make a decision based on ISO 27001 is influenced by all prior experiences of the individual, the organisation the individual works in and the current situation (person - situation - organisation paradigm) (cf. Berger and Luckmann 2004; Hacker 2005; Watzlawick 2007).

This is also true for situations where new security standards are created, e.g. the finding of new encryption standards like AES or the decision if a web browser supports SSL 1.0, 2.0, 3.0 and/or TLS 1.0, 1.1 or 1.2.

So, every step of analysing or measuring security is about humans making decisions and how their decision making is influenced by their biography. The only science that is able to research these topics (human behaviour and decision making) is psychology. This means that psychology is *required* if we want to do scientific sound research about security.

1.1 Ignaz Semmelweis - Or why Physicians don't Want to Wash Their Hands

Besides IT security there are some historical examples where these reflections also come into play. The life of Ignaz Semmelweis is an excellent example of what can happen when a scientist wants to change a paradigm.

Ignaz Semmelweis, an Austro-Hungarian physician, is nowadays known as »saviour of the mothers[1]«.

In 1846 he was appointed assistant to Prof. Johann Klein in the first obstetrical clinic of the Vienna General Hospital. During that time, free obstetrical clinics were set up at different hospitals in Europe, mostly to combat the high rates of infanticide, illegal abortions and cot death. The clinics were frequently used by women from low income families, as well as prostitutes. In return for the free treatment at the hospital the patients were used as subjects in doctor's training. However, the first obstetrical clinic of the hospital had a much higher average maternal mortality rate than the second clinic (ca. 10% with ranges from 5-30% vs. 4%). This was also known outside of the clinic, where women begged on their knees to be admitted to the second clinic instead of the first one. Some women where so desperate that they preferred to give birth on the streets and be submitted to the hospital once the birth was over.

1 Popularised as the title of an East German film from 1950

Semmelweis also realised that there was a much higher mortality rate at the first clinic and he was puzzled that even the women who gave birth on the streets had a lower mortality rate. So he begun a systematic research to identify the factors that lead to the different mortality rates. His good friend Jakob Kolletschka, also a medical doctor in the hospital, died in 1847 after he was accidentally cut with a scalpel during a post mortem examination. The autopsy of Kolletschka showed a pathology similar to that of puerperal fever. Semmelweis immediately made a connection between cadaveric contamination and puerperal fever. The deciding factor for the different mortality rates were the medical doctors who worked in the first clinic and did autopsies as well as delivering babies. The second clinic trained midwives, who did no autopsies. So the midwives could not transmit the cadaveric contamination to the women during child birth. During this time, Prof. Klein transformed obstetrics into a more anatomical oriented discipline that focusses more on pathological autopsies. The mortality rate drove even higher during that time.

Semmelweis concluded that some kind of »cadaverous material« is transmitted by doctors partaking in autopsies. The germ theory of disease was not fully developed in these days, Louis Pasteur and Robert Koch would only begin to work on these topics decades later. Semmelweis instituted a policy of washing hands with calcium hypochlorite (also known as chlorine powder or bleach powder) which reduced the mortality rate from 18.3% to 2.2%. Table 1 shows the number of births and deaths in the first and second clinic during Semmelweis' research (Semmelweis 1861).

The important part, however, is the acceptance of Semmelweis' findings. Since the germ theory of disease was not fully developed yet, there was no logical explanation available for the reason of his findings. Experts in these times still considered the ancient theory of four humours to be true. This theory claimed that the four humours of a person have to be in balance and that every disease is unique, since the four humours of every person differ. The accepted theory of disease was the theory of Miasma or bad air. According to this theory, bad air transmitted the cause for disease, including cholera, black death or puerperal fever. So Semmelweis' findings stood contrary to every accepted medical theory of that time and even offended some doctors, who considered themselves to be gentlemen and therefore required no hand washing.

Since Semmelweis himself did not publish a paper on his work until 1861, other physicians only got to know about his findings from translated second hand reports, which also lead to misunderstandings (Semmelweis 1861). Another factor was the political turmoil of the Vormärz period, the March revolution and the Hungarian Revolution. Johannes Klein, still Semmelweis' superior, was known to be a conservative, and probably did not like or trust Semmelweis - who was a Hungaro-Austrian. Klein denied the extension of Semmelweis two year term and instead appointed Carl Braun, who believed miasma caused puerperal fever. Semmelweis in turn petitioned the Viennese authority to be appointed as *Privatdozent*. It took him 18 month until he was appointed as Privatdozent of *theoretical* obstetrics - where he had no access to cadavers and autopsies. Semmelweis left Vienna, returned to Pest and took over the Szent Rókus Hospital, where he installed his methods and virtually eliminated puerperal fever. However, his fellow Hungarian obstetricians did not accept his new methods.

Many other obstetricians misunderstood his findings or publicly ridiculed him, including Rudolf Virchow, director of the Institute for Pathology of the Charité Berlin and so called »Pope of medicine«. Beginning from 1861, Semmelweis' mental health deteriorated and he published several open letters to the medical community. In 1865, János Balassa referred Semmelweis to a mental institution. Ferdinand Ritter von Hebra lured Semmelweis into the Landes-Irren-Anstalt in der Lazarettgasse in Vienna, where Semmelweis was severely beaten and forced into a straitjacket. Semmelweis died two weeks later of blood poisoning, possibly caused by the beatings in the mental asylum.

2 Perception of Security

Our research is concerned with the human perception of security . Each individual perceives the world in its own way, shaped by its own former experiences. We will follow the footsteps of von Foerster and Watzlawick and try to explore the world view of IT users and their perception of security. To explore this perception, we have to use methods of qualitative research.

As Hancock (2002, p 2) lays out,

> Qualitative research is concerned with developing explanations of social phenomena. Its aim is to help us to understand the world in which we live and why things are the way they are. It is concerned with the social aspects of our world and seeks to answer questions about:
>
> - Why people behave the way they do
> - How opinions and attitudes are formed
> - How people are affected by events that go on around them
> - How and why cultures have developed in the way they have
> - The differences between social groups
>
> Qualitative research is concerned with finding the answers to questions which begin with: why? how? in what way? Quantitative research, on the other hand, is more concerned with questions about: how much? how many? how often? to what extent? Fur-

	First clinic			Second clinic		
Year	Births	Deaths	Rate in %	Births	Deaths	Rate in %
1833	3,737	197	5.3	353	8	2.3
1834	2,657	205	7.7	1,744	150	8.6
1835	2,573	143	5.6	1,682	84	5.0
1836	2,677	200	7.5	1,67	131	7.8
1837	2,765	251	9.1	1,784	124	7.0
1838	2,987	91	3.0	1,779	88	4.9
1839	2,781	151	5.4	2,01	91	4.5
1840	2,889	267	9.2	2,073	55	2.7
1841*	3,036	237	7.8	2,442	86	3.5
1842	3,287	518	15.8	2,659	202	7.6
1843	3,06	274	9.0	2,739	164	6.0
1844	3,157	260	8.2	2,956	68	2.3
1845	3,492	241	6.9	3,241	66	2.0
1846	4,01	459	11.4	3,754	105	2.8
1847*	3,49	176	5.0	3,306	32	1.0
1848	3,556	45	1.3	3,319	43	1.3
1849*	3,858	103	2.7	3,371	87	2.6
1850	3,745	74	2.0	3,261	54	1.7
1851	4,194	75	1.8	3,395	121	3.6
1852	4,471	181	4.0	3,36	192	5.7
1853	4,221	94	2.2	3,48	67	1.9
1854	4,393	400	9.1	3,396	210	6.2
1855	3,659	198	5.4	2,938	174	5.9
1856	3,925	156	4.0	3,07	125	4.1
1857	4,22	124	2.9	3,795	83	2.2
1858	4,203	86	2.0	4,179	60	1.4

Table 1: Birth and Death rates in the first and second clinic during Semmelweis' research
1841: only midwives worked in second clinic, medical doctors in first
1847, May: Semmelweis installed hand washing policy
1849, March: Semmelweis is dismissed from clinic

ther features of qualitative research and how it differs from quantitative research are listed below.

- Qualitative research is concerned with the opinions, experiences and feelings of individuals producing subjective data.
- Qualitative research describes social phenomena as they occur naturally. No attempt is made to manipulate the situation under study as is the case with experimental quantitative research.
- Understanding of a situation is gained through an holistic perspective. Quantitative research depends on the ability to identify a set of variables.
- Data are used to develop concepts and theories that help us to understand the social world. This is an inductive approach to the development of theory. Quantitative research is deductive in that it tests theories which have already been proposed
- Qualitative data are collected through direct encounters with individuals, through one to one interviews, group interviews or by observation. Data collection is time consuming.
- The intensive and time consuming nature of data collection necessitates the use of small samples.
- Different sampling techniques are used. In quantitative research, sampling seeks to demonstrate representativeness of findings through random selection of subjects. Qualitative sampling techniques are concerned with seeking information from specific groups and subgroups in the population.
- Criteria used to assess reliability and validity differ from those used in quantitative research
- A review of textbooks reveals a variety of terms used to describe the nature of qualitative and quantitative research. [...]

Qualitative research offers a wide range of different methods. We plan to utilise several methods, including semi-structured and unstructured interviews with a special focus on autobiographical narrative interviews according to Fritz Schütze (Schütze 1983).

We want to interview hacker, researchers and »normal« IT-users to reconstruct their perception of security and how they biographise their learning processes about IT and IT security.

Some of the research questions are:

- What shapes a Hacker's mind?
- How do users perceive IT security?
- How can this perception be changed?
- How is security awareness formed?
- How can awareness be transferred into concrete action?

Another point of our research programme will be the quantitative correlation of personality and security. Different models and theories of personality exist in personality and differential psychology. Personality traits have been well researched and several sound empirical tools exist. The five-factor model (FFM) - also known also Big 5 - is a widely used questionnaire that examines openness, conscientiousness, extraversion, agreeableness and neuroticism. The model is quite extensively used in industrial psychology and in vocational counselling to examine the person-organisation-fit.

We want to do a quantitative research and correlate personality traits and models with security relevant behaviour.

3 Didactics of Security – Towards Security Competence

Didactics is the science of learning, teaching and teaching methodology. It is the scientific discipline that turns someone who knows something into a professional teacher. It is therefore required to develop scientific sound teaching methods, if IT security shall be professionalised.

Fortunately, Germany has a very rich tradition of didactical research, thanks to our dual system in technical and vocational education and training. Trainees are trained on the job for 3 to 3.5 years in their training company and spend, on average, 2 days per week in a TVET school. The TVET schools teach theoretical backgrounds according to a federal curriculum.

There are already several IT professions and corresponding curricula in the German TVET system. Some of them already include IT security to a certain degree. The curricula need to be modernised and the teaching of IT security has to be intensified.

Since 1997, all German TVET curricula are based on the so called model of competencies[2]. This competence model requires German TVET teachers to also teach studying and research methods and put a heavy emphasize on autonomous learning and ability to perform. Trainees learn *how* to keep their knowledge up to date and to know what to learn (cf. Sekretariat der Kultusministerkonferenz 2007).

So all we have to do is to take the well established methods from general didactics and bring them together with subject didactics of related fields (computer science, maths, electrical engineering, IT etc.) to create a scientific sound subject didactics of IT security. The outcome of this research will be a model

2 Competencies according to the psychological meaning of capabilities, skills, being able to do something on ones own.

of security competence, based on the aforementioned model of competencies: social competence, professional competence, methodological competence, self-competence and occupational competence.

To achieve this, we need to discuss *how* we can teach security, *who* has to learn about IT security and *what* has to be taught and learned, and finally *how* to test the learning outcomes?

This requires a thorough analysis of existing teaching methods and their possible application to IT security. We want to examine well established methods, like masterpieces, project based work, action oriented teaching and blended learning. We also have to discuss who has to learn what about IT security, this can be established by creating roles such as system administrator, end user, developer, network specialist etc. pp. The most interesting - and challenging - part will be the development of scientific sound evaluation methods to measure the learning output. Once again, the current German TVET didactics come into play when we want to use competence diagnostics to achieve this goal (cf Erpenbeck and Sauter 2007; Erpenbeck and von Rosenstiel 2007; Kirchhöfer 2004; Langens et al. 2003; North 2002; North and Reinhardt 2005; Sonntag et al. 1997; Staudt et al. 2002).

4 Organisational Development

IT Security is of course an important and currently hot topic in companies. A lot of money is spent on security awareness trainings that are mostly neither scientific sound nor scientificly evaluated. Some are even simple fraud.

We want to evaluate existing methods for knowledge management and organisational development and asses their value for security awareness and security competence development in organisations.

Much like Senge (1990) and his concept of a learning organisation, we emphasize the need of organisational development and propose the concept of a *security competent organisation*: An organisation able to identify security incidents and react to them to prevent further harm.

A factor that often occurs during organisational consulting and development is the insurance approach of management. Many managers are more interested in getting a certificate (a piece of paper with many stamps on it) that insures them, than rather doing a real organisational development. Max Weber described this phenomenon in his discussion of leaderships style, Ulrich Beck reflected upon insurability and Niklas Luhmann on risk (cf. Beck 1986, 2007; Luhmann 2003; Weber 1947a,b).

5 Cultural Differences

Cultural differences and awareness of them are nowadays well known and cultural sensitivity trainings are well established. This has to be taken into account when developing security trainings. Different cultures have different approaches to security and not every country or company follows the same management style.

6 IT Security as a Scientific Discipline of Its Own

IT Security needs to become a scientific discipline of its own. IT Security is a transdisciplinary, integrative science, like, for example, political science, which integrates jurisprudence, philosophy and economy.

IT Security requires it's own research methods, especially on the points of contact of different research fields, like man machine interaction or curricula development for technical systems. It would connect fields like Maths as formal science, computer science and electrical engineering as engineering sciences, sociology and political science as social science, jurisprudence as normative science, of course philosophy as mother of all sciences and psychology as the hub science bringing everything together.

Fig. 1 shows the different branches of IT security and their sub-branches.

7 Knowledge Base

A minor part of our research programme, but none the less an important one, is the creation of a base of knowledge. A huge psychological/didactical problem is the handling of knowledge floating around. Especially in the open source and/or security scene, a lot of information can be found online in blogs, usenet groups, on websites or discussion forums. Much of this information is outdated, wrong or simply contradicting. But end users or experts have to deal with this contradictory state of facts.

Besides addressing this fact already in the Didactics part of our programme, we will evaluate the creation of a knowledge base. To set up an effective one, we need to find methods to identify correct knowledge and find experts who are able to evaluate facts and knowledge.

8 About the Author

Stefan Schumacher is head of the Magdeburger Institut für Sicherheitsforschung (Magdeburg Institute for Security Research) and currently running a research programme about the psychology of security. This includes social engineering, security awareness and qualitative research about the perception of security.

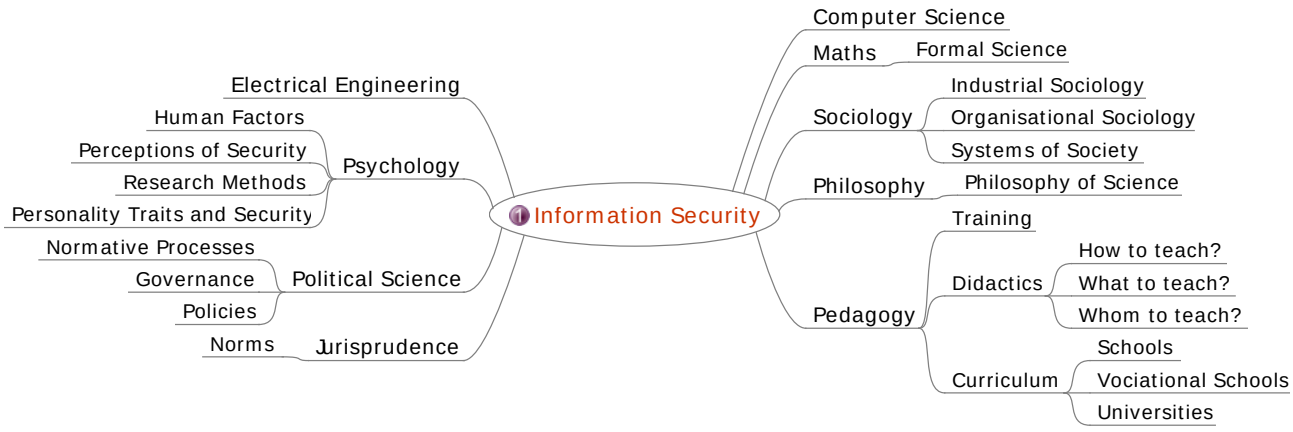


Figure 1: Branches of Information Security as a Scientific Discipline

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