Modeling The Erosion of Safe Sex Practices

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Abstract

As starting hypothesis, we argue that the erosion of safe sex practices for people having frequent change of sexual partner might be explained in terms of two mechanisms: instrumental conditioning through "reward" (greater sexual pleasure) following unprotected sex and misperception of the risk to become infected by HIV due to low infectivity of HIV and long delays (long latency and incubation period). A causal-loop diagram is developed and discussed. However, the formulation of a stock-and-flow model requires a detailed discussion of the modern theory of instrumental conditioning (the behavioral regulation approach). Surprisingly, the behavioral regulation approach suggests as actual mechanism responsible for erosion of safe sex practices the return to the "behavioral bliss point" (zero condom use) due to a gradually declining perception of risk. Such misperception of risk impacts on the instrumental contingency (acceptance of safe sex).

We propose counteracting policies in accordance with the behavioral regulation theory of instrumental conditioning mediated by risk perception. We also discuss the relation of this paper to a parallel paper on erosion of information security and safety (i.e. organizational accidents).

Keywords

Erosion of safe sex; Instrumental conditioning; Misperception of risk.

Introduction

Sexually transmitted diseases (STDs) are markers for high-risk sexual practices that facilitate HIV-transmission. Indeed, "traditional" STDs (syphilis, gonorrhea and clamydia) have short incubation periods, i.e. incidence studies of such STDs provide an up-to-date view of current (un)safe sex behavior. Following the advent of the HIV epidemic, rates of STDs among male homosexuals declined during the early 1980's. Reports from several US cities and major cities in Europe and elsewhere documented a pronounced decline in e.g. gonorrhea (Judson 1983; Centers for Disease Control 1984; Handsfield 1985). Further, parallel studies documented reductions in unsafe sex behaviors (Martin, Garcia, and Beatrice 1989; McKusick et al. 1990). One had reasons to believe that the advent of the HIV epidemic, with ensuing efforts to promote safe(r) sex practices, had led to an apparently permanent behavior change – an optimistic signal concerning the possibility to counteract the spread of the HIV epidemic.

However, more and more recent studies document a reversal of these trends, viz. increases in syphilis, gonorrhea and clamydial infection among male homosexuals (Williams et al. 1989; Fox et al. 2001; Centers for Disease Control 1999a, 1999b).

It appears that the proportion of people at risk that practice safe sex has been declining. Several studies have observed an increase in unprotected anal intercourse among male homosexuals (Centers for Disease Control 1999a; Wolitski et al. 2001). Unfortunately, these studies do not provide more than a few scattered observations over time, i.e. there are no systematic longitudinal studies of condom use of male homosexual cohorts. Lacking time series of condom use, the rationale for postulating a decreasing trend in condom use over longer period of times is the much better data for increasing incidence of STDs.

Several potential mechanisms for the increase of risky sexual behaviors have been proposed, e.g. fatigue with safe sex messages and practices (Sowell, Lindsey, and Spreer 1998), optimism about new therapies with consequent reduction of fear of acquiring and transmitting HIV infection (Kraverk et al. 1998; Kelly et al. 1998) as well as demographic, psychosocial and situational factors. These hypotheses might have some validity, but they are difficult to test. In addition, they sound somewhat ad hoc and construed. Also, they fail to explain why increase of risky behavior already occurred many years ago – at a time when there were so-to-speak no treatments of HIV-infection proper. (Even today, anti-HIV therapies do not cure the fatal disease.) Accordingly, a fundamental explanation of the observed increase of risky sexual behaviors is needed.

In a previous paper (Gonzalez 1995) we have suggested a different explanation of the phenomenon of erosion of safe sex practices. Our explanation invoked two seemingly well-established mechanisms, viz.:

1. Instrumental conditioning (a.k.a. operant conditioning): 'Safe sex' – i.e. consistent condom use – it depends on both sexual partners being compliant, it requires that condoms are at hand, it is unpopular because condom use inhibits sexual pleasure, etc. Bypassing such impediments should be rewarding, i.e. departing from 'safe sex' would act as a reinforcing stimulus (a 'reinforcer'), which reinforces the response of having unprotected sex.
2. Misperception of risk: HIV has very low infectivity, that is, single potentially infectious contacts will rarely result in HIV infection. In addition, the long latency and incubation period for AIDS counteract a reasonably correct risk perception. It is well-known that people have great problems in assessing probabilities of unlikely events: Research initiated with the formulation of Tversky's and Kahneman's prospect theory shows that people in the face of very unlikely events either overestimate probability of their occurrence or neglect it at all (Kahneman, Slovic, and Tversky 1982; Kahneman and Tversky 2000).

Speculative Modeling

Admittedly, there is little empirical data for calibrating a system dynamical model of erosion of safe sex practices. We have already mentioned the lack of longitudinal studies of condom use in male homosexual cohorts. But also crucial behavior

parameters, such as e.g. perception of risk for infection with HIV, strength of compliance with recommended safe sex practices, etc., are quite unknown.

Nevertheless, we argue that it does make sense to develop a system dynamic model based on the indirect data (observed increase in incidence of STDs) that is available – even if it requires speculative modeling.

The following (adapted) quotation from a recent book on music in mind and culture by the cognitive scientist William Benzon (Benzon 2001, p. iii) gives an excellent rationale for speculative modeling as well: "This [paper] is speculative because it must be. There is no other way to approach questions where our need and our interest exceed our current evidence. The purpose of speculation is to clarify thought. If the speculation itself is clear and well-founded, it will achieve its end even if it is wrong, and many of my speculations must surely be wrong. If I then ask you to consider them, not knowing how to separate prescient speculations from mistaken ones, it is because I am confident that we have the means to produce ideas that are interesting, significant, and clear enough to justify the hard work of investigation, both through empirical studies and through computer simulation."

The procedure followed in this paper is in accordance with another quotation from Benzon's book (Benzon 2001, p. ii): "I have used empirical evidence wherever available, but the evidence available scarcely covers the ground. There are gaping holes that I can only fill in with speculation."

Reference Behavior Mode

Our proposed reference behavior modes are as follows:

1. We intend to model an individual's condom use along a time horizon of typically 5-6 years time. The individual is supposed to be an average member of a male homosexual cohort undergoing erosion of safe sex practices.
2. As reference behavior mode we consider compliant individuals (deviations from safe sex practice are corrected) and non-compliant individuals (exhibiting gradual decline of condom use).
3. For non-compliant individuals we suggest that occasional alarming "incidents" – e.g. media reports, second-hand knowledge of AIDS cases – lead to transient compliance with recommended safe sex practices. Patterns of long-term decay of safety awareness with interspersed transient improvements of safety awareness triggered by (minor) incidents until a major accident occurs remind of the behavior of an "unrocked boat".[1]

Causal-loop diagram

A naïve interpretation of the theory of instrumental conditioning would read as follows:

Following the advent of the AIDS epidemic people conform to safe sex practice. As time passes, incidents will happen – the condom might break during use, or being drunk couples might not use condom. Such occurrences – though scaring at first – will

[1] Reason (Reason 1997) gives Constance Perin credit for coining the metaphor of the "unrocked boat" (opus cit., p. 20, note 4).

act as reinforcers of less condom use through the experienced greater sexual pleasure. Accordingly, frequency of condom use will decrease over time. At this stage the individual might still perceive the risk of becoming infected by HIV as relatively high, i.e. the individual will still use condoms, though inconsistently. Later on, misperception of risk leads to still less condom use, etc.

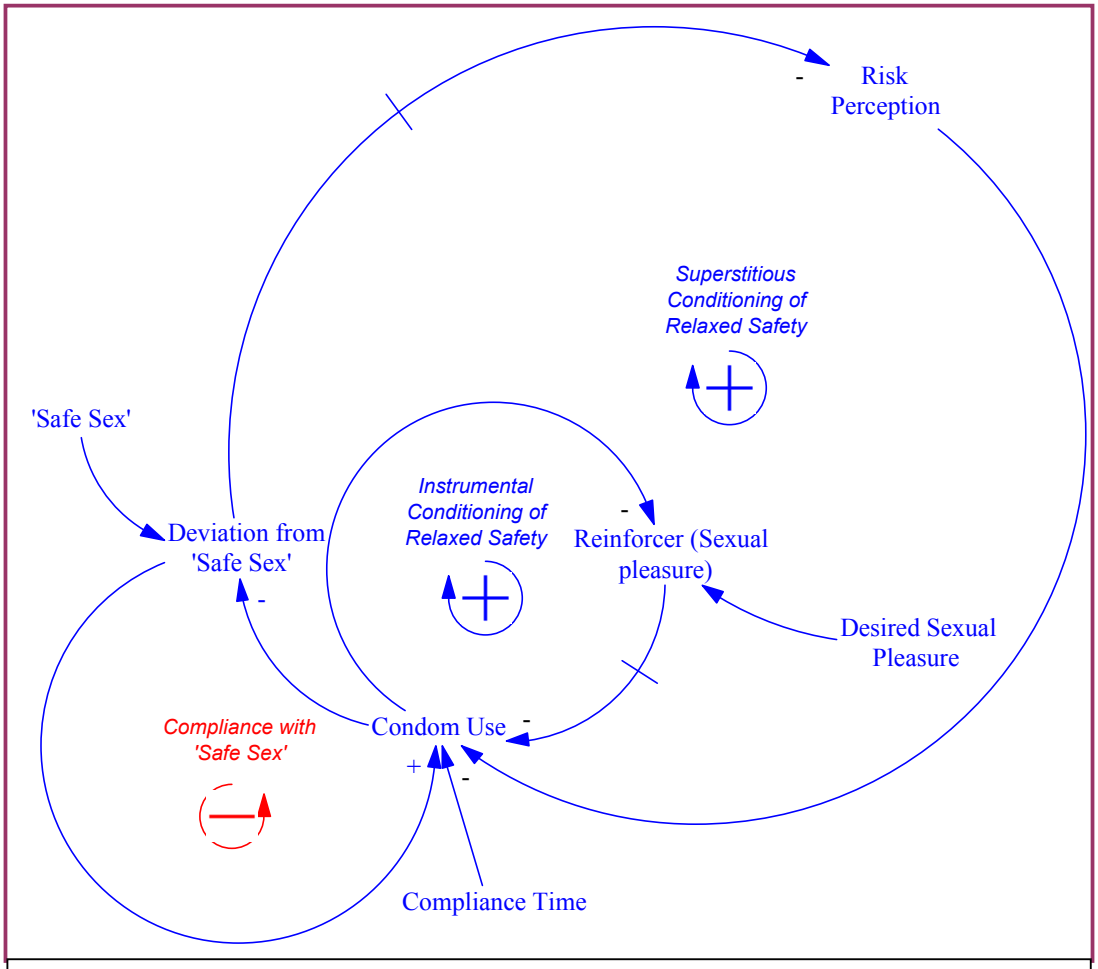

Figure 1 Basic loops for the erosion of 'safe sex' practices.

Consider Figure 1: The *'Safe Sex'* parameter is assumed to be exogenous, corresponding to the recommended practice of always using condom when having sex (unless one is certain that there is no risk of HIV infection). Accordingly, *'Safe Sex' = 100%* condom use. Deviations from safe sex (i.e. *'Condom Use' < 'Safe Sex'*) are counteracted accordingly to the balancing loop "Compliance with 'Safe Sex' ". A reinforcing loop, "Instrumental Conditioning of Relaxed Safety", expresses that less condom use is rewarding and promotes even less condom use. We make allowance for a slight delay between the reinforcing stimulus (sexual pleasure) and the ensuing response of less condom use. A second reinforcing loop, acting with a substantial delay (involving the formation of low risk expectation as the subject "discovers" that unsafe sex after all does not seem to have consequences) gives additional impetus to the deviation from safe sex practices. Since this loop involves misperception of risk

and, hence, is a form of superstitious learning, we call it "Superstitious Conditioning of Relaxed Safety". (Hogarth 1987)

Note that the CLD from Figure 1 is in principle applicable to any STD – not just HIV/AIDS. Both positive feedback loops, viz. "Instrumental Conditioning of Relaxed Safety" and "Superstitious Conditioning of Relaxed Safety" include delays. The delay in the first loop should be relatively short (hours or a few days). The delay in the loop "Superstitious Conditioning of Relaxed Safety" will involve formation of risk perceptions and, hence, be considerably longer. For traditional STDs the formation of risk perceptions will take days or weeks, while the misperception of the infection risk associated with HIV could involve many months or even years.

The causal loop analysis above seems to make sense. Interestingly, the transition to a stock-and-flow model will lead us to quite a different interpretation and to novel insights.

The Behavioral Regulation Theory of Instrumental Conditioning

The basic elements of Pavlovian (classical) conditioning are familiar to most educated persons. Many people are also reasonably conversant with instrumental conditioning. However, there are many misconceptions concerning conditioning – both classical conditioning and instrumental conditioning (Domjan 2000).

For the purpose of modeling the mechanism of instrumental conditioning one needs an accurate understanding of the currently accepted theory of instrumental conditioning – viz. the behavioral regulation approach (Allison 1989; Timberlake 1980, 1984).

In the remainder of this section, we quote from and adapt the discussion that is provided in the excellent book by Domjan on conditioning and learning (Domjan 2000):

A theory of reinforcement has to explain: (1) what makes something a reinforcer and (2) how a reinforcer produces its effects. Early theories assumed that reinforcers were special kinds of stimuli. According to the most influential of these theories (Hull 1943), a stimulus will be reinforcing if it is effective in reducing a drive state. Drive reduction theory was prominent for several decades but ran into difficulties (it could not explain sensory reinforcement, e.g.) and was supplanted by response views of reinforcement. A prominent response view was Premack's differential response probability principle (Premack 1965). According to this principle, a reinforcer is not a drive-reducing stimulus but is the opportunity to make a response that has a higher baseline probability that the baseline probability of the instrumental response.[2]

The Premack principle formed the basis of numerous applications of reinforcement in clinical and educational settings. However, difficulties with measuring response probabilities stimulated the next theoretical development, the response deprivation hypothesis (Timberlake and Allison 1974). According to this hypothesis, the opportunity to perform a response will be an effective reinforcer if the instrumental

[2] Quoted and adapted from (Domjan 2000), Ch. 8, p. 133-4.

conditioning procedure restricts access to that activity below its baseline rate. The response deprivation hypothesis shifted the focus of attention from reinforcers as special stimuli or responses to how an instrumental conditioning procedure restrains an organism's activities. This idea was developed further in the behavioral regulation approach. In fact, as was true of the Premack principle, the response deprivation hypothesis only provided an answer to the first question – "What makes something effective as a reinforcer?" The answer to the second major question – "How does a reinforcer produce an increase in the probability of the reinforced response?" – had to await development of the behavioral regulation approach.[3]

According to the behavioral regulation approach (Timberlake 1980, 1984; Allison 1989), organisms have a preferred distribution of activities in any given situation. The introduction of an instrumental conditioning procedure disrupts this preferred response distribution or "behavioral bliss point." Typically, the adjustment to the disruption is that the rate of the instrumental response increases whereas the rate of the reinforcer response decreases.[4]

The behavioral regulation approach borrowed the concept of homeostasis from physiology and drive reduction theory and extended it to response choice. Behavioral homeostasis is analogous to physiological homeostasis in that both involve defending the optimal or preferred level of a system. Physiological homeostasis exists to maintain physiological parameters (blood levels of oxygen and glucose, e.g.) close to an optimal or ideal level. The homeostatic level is "defended" in the sense that deviations from the target blood levels of oxygen or glucose trigger compensatory physiological mechanisms that return the systems to their respective homeostatic levels. In behavioral regulation, what is defended is the organism's preferred distribution of activities, its behavioral bliss point. The behavioral bliss point refers to how an organism distributes its activities among available response options.[5]

Instrumental conditioning procedures constrain response options. They disrupt the free flow of behavior and interfere with how an organism selects among its available response alternatives. In other words, the instrumental conditioning procedure does not allow the participant to return to the behavioral bliss point. The best that can be achieved is to approach the bliss point under the constraints of the instrumental conditioning procedure.[6]

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[3] Quoted and adapted from (Domjan 2000), Ch. 8, p. 134 and p. 129.
[4] Quoted and adapted from (Domjan 2000), Ch. 8, p. 134.
[5] Quoted from (Domjan 2000), Ch. 8, p. 130.
[6] Quoted from (Domjan 2000), Ch. 8, p. 131.

Domjan (Domjan 2000) gives as example a teenager ("Kim") who spends half an hour a day doing school work whereas she devotes as much as 3 hours a day listening to music. Her parents would like to introduce an instrumental conditioning procedure to increase the amount of time Kim spends doing school work. See Figure 2.[7]

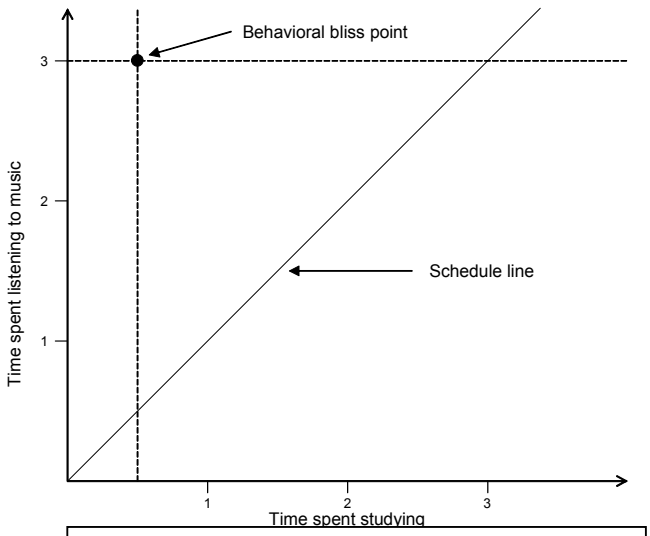

Figure 2: The bliss point represents how much time a person spends studying and listening to music in the absence of an instrumental conditioning procedure or schedule constraint. The schedule line represents how much time the person can devote to each activity when she is required to spend one minute studying for each minute spent listening to music.

How Kim's behavior changes after an instrumental contingency has been imposed depends on the costs and benefits of various strategies. If school work is much more unpleasant for Kim than the potential loss of music listening time, then she will not increase her school work much but rather give up time listening to music. But if potential loss of music time is much more aversive for Kim than increase of school work, she will adjust to the constraint imposed by the conditioning procedure by substantially increasing her time doing school work.[8]

Stock-and-flow Model

In order to model the erosion of safe sex practices as instrumental conditioning we need to determine the behavioral bliss point and the instrumental contingency. The behavioral bliss point for male homosexuals would be 'no use of condoms' – i.e. assuming no (perceived) threat of infection from sexually transmitted diseases (including HIV infection), the preferred mode of sexual intercourse would be without condom.

Accordingly, we introduce a (constant) parameter:

'Behavioral bliss point' = 0 <<pct>> // The unit 'pct' stands for percentage

(Notice that we express units throughout using the notation <<*unitname*>> whereas // stands for a comment.)

The instrumental contingency is (the strongly recommended) consistent use of condom in all sexual intercourse with potentially infectious partners. For simplicity, we ignore complications like a subject having partners that he trusts are not infectious

[7] We remind the reader that this figure – and most part of the review of theories of instrumental conditioning found in the present section are borrowed from (Domjan 2000, Ch. 8).
[8] Quoted and adapted from (Domjan 2000), p. 132.

as well as numerous other partners he must consider to be potentially infected. In other words, we assume a situation with people having frequent change of partners in a city with a high degree of HIV prevalence.

Accordingly, we introduce a (constant) parameter:

'Safe sex level' = 100 <<pct>>

Notice that the reasoning above shows that our point of departure – the introductory causal analysis – was somewhat naïve.[9] Rather than having a preferred behavior of consistent condom use that is gradually eroded due to instrumental conditioning, the behavioral regulation theory of instrumental conditioning suggests that the observed erosion of safe sex practices must be interpreted as a return to the behavioral bliss point ('no use of condom') as a consequence of a gradual weakening of the strength of the instrumental contingency: The subject becomes more aversive toward safe sex as the perceived rationale for it withers away. This insight deriving from the behavior regulation theory of instrumental conditioning has important consequences for how the erosion of safe sex practices might be counteracted (cf. Section "Policy Analysis" below).

We suggest that the main mechanism debilitating the strength of the instrumental contingency is misperception of risk. Initially, subjects adopt safe sex practices because they perceive the danger of HIV infection as high and the consequences of HIV infection as unacceptable. As time passes, several mechanisms erode such perception of risk, probably the most important being the ubiquitous human tendency to discount risks that are not manifest most of the time – if 'non-events' dominate, even potentially fatal threats pale.

The performance of the subject is captured in the variable *'Protection level'*, expressing the percentage of use of condom in sexual intercourse. As persistent trait, *'Protection level'* should be a stock. *'Protection level'* is affected by two processes (i.e. flows). The outflow '*Erosion of protection level'* describes the attraction of the subject's behavioral bliss point, whereas the inflow '*Build-up of protection level'* is the opposing process of compliance with safe sex recommendations. The resultant of these two flows determines the dynamics of the subject's behavior in terms of his percentage use of condom (*'Protection level'*). (See Figure 5, p. 12.)

Accordingly,

'Protection level' = 'Protection level' + dt•'Build-up of protection level' - dt• 'Erosion of protection level'

where, for simplicity, we have omitted time indices in the level variable.

Since we intend to describe the observed phenomenon of erosion of safe sex practices from full compliance to risky sexual behavior, it is natural to assume that '*Protection level'* initially equals *'Safe sex level'* (i.e. 100% condom use).

[9] The introductory causal analysis might appeal at first sight because it conforms to a prevalent misconception in the general educated public of how instrumental conditioning works.

The rate equations for *'Erosion of protection level'* and *'Build-up of protection level'* are standard, viz.:

'Erosion of protection level' = *'Deviation from behavioral bliss point'*'Attraction toward bliss point'*

'Deviation from behavioral bliss point' = *'Protection level'-'Behavioral bliss point'*

where *'Attraction toward bliss point'* is an inverse time constant. How *'Attraction toward bliss point'* depends on the perceived risk will be discussed later.

Further,

'Build-up of protection level' = *('Safe sex level'-'Protection level')*'Degree of compliance with safe sex'*

where also *'Degree of compliance with safe sex'* is an inverse time constant.

It is natural to assume that *'Degree of compliance with safe sex'* depends on the perceived risk. HIV being a retrovirus and member of the lentivirus family, there is little reason to expect more from future drugs than a further delay in the 'default' long incubation period of AIDS disease (Koch 1987). (HIV infection, if untreated, implies an average incubation period toward AIDS of more than ten years). For some people in high risk groups, various factors – low infectivity of HIV, long incubation period, optimistic expectations concerning future treatments – compound to shape perceived risk as less and less intimidating over time. Accordingly, for such people the instrumental contingency is not strong enough to sustain safe sex behavior, i.e. *'Protection level'* will after some time decay to a level near the behavioral bliss point.

Other subjects would perceive the risk of becoming HIV infected and the consequences of HIV infection so unacceptable that the level of protection will stay close to full protection, i.e. *'Protection level'* will decay little (ideally nothing) reaching asymptotically a stationary value:

'Protection level' ≈ *'Safe sex level'*

The reasoning above suggests that both *'Degree of compliance with safe sex'* and *'Attraction toward bliss point'* must be dependent on the perceived risk. Arguably, the degree of compliance with safe sex is mainly the result of a rational stance while the "attraction toward bliss point" (i.e. because unprotected sex means greater sexual pleasure) is an emotional attitude.

In the absence of empirical studies some speculation is needed: It is reasonable to expect that *'Degree of compliance with safe sex'* will be zero if the subject perceives the threat of HIV infection as non-existent. Further, one would expect that *'Degree of compliance with safe sex'* will not undergo dramatic changes for small values of the perceived risk, i.e. that *'Degree of compliance with safe sex'* should increase slowly as function of the perceived risk in the low end of the abscissa. Jumping to high values on the abscissa, if the subject perceives the threat of HIV as very high *'Degree of*

compliance with safe sex' would be high, implying that one should have an S-shaped curve. The asymptotic right end of the curve would describe immediate return to safe sex if by human failure the subject would have indulged in an occasional unprotected sexual intercourse. Remembering that *'Degree of compliance with safe sex'* is an inverse time constant one would expect in the asymptotic high end:

'Degree of compliance with safe sex' ≥ 1 *<<hr^{-1}>>*

expressing return to safe sex within one hour of a faux pas.

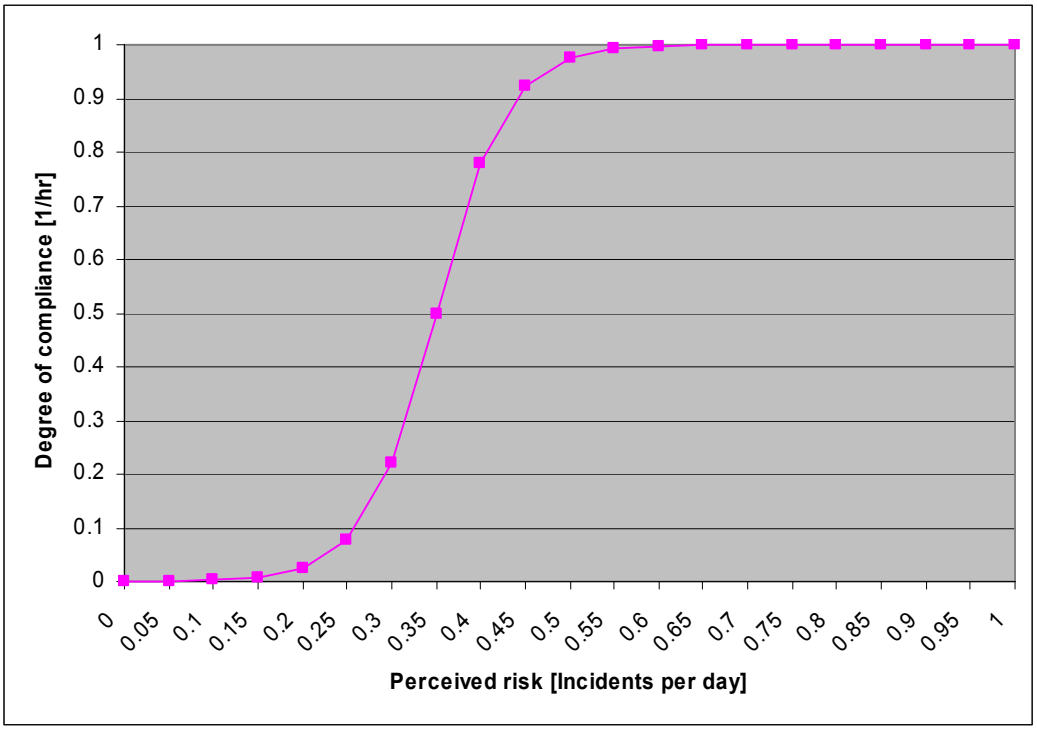

Figure 3 Logistic curve *'Degree of compliance with safe sex'* vs. *'Perceived risk'*.

Figure 3 displays a logistic relationship between *'Degree of compliance with safe sex'* and *'Perceived risk'* satisfying the requirements expressed above. Or, as analytical expression:

*'Degree of compliance with safe sex' = (1 <<1/hr>>)/(1 + EXP(-25 <<da>> *('Perceived risk' - 0.35 <<1/da>>))) // Perceived risk in <<1/hr>>*

where *<<da>>* and *<<hr>>* mean day and hour units, respectively.

It remains to specify how *'Attraction toward bliss point'* depends on the perceived risk: Very high perceived risk acting as instrumental contingency should not only impose a very quick return to safe sex (as described above) but also make unprotected sex (the behavioral bliss point) less attractive. For very low perceived risk the behavioral bliss point should dominate entirely. Again, one would expect an S-shaped curve, this time starting with a high value and going asymptotically toward zero. Figure 4 displays a possible relationship satisfying such requirements (and – as we will see below – leading to simulation results in the right order of magnitude).

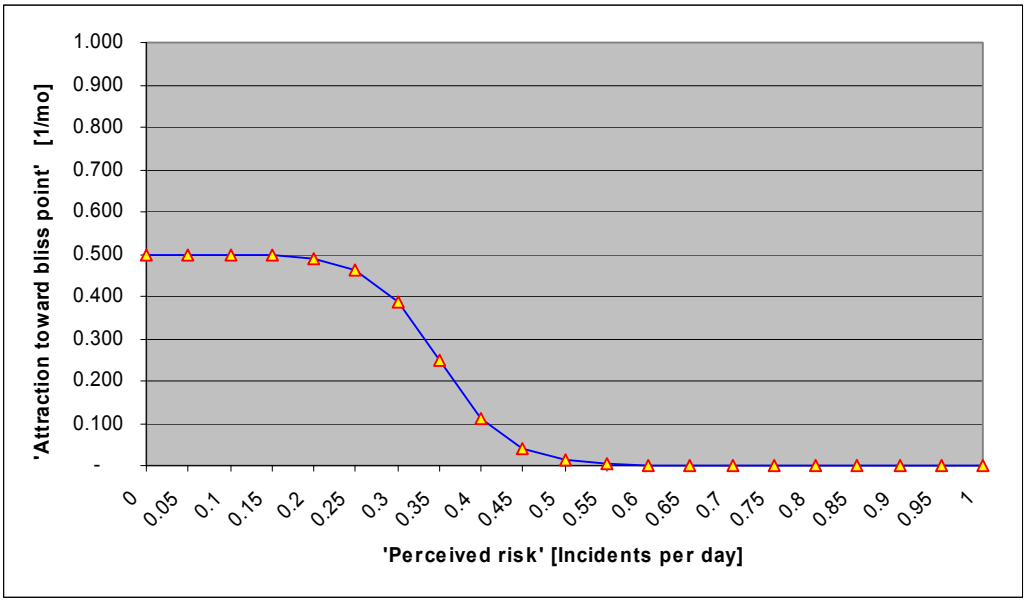

Figure 4 Inverse S-shape relationship for *'Attraction toward bliss point'* vs. *'Perceived risk'*.

So far, the variable *'Perceived risk'* has been undefined. As expressed before, we assume that the subject in question originally perceives the risk of becoming HIV-infected through unprotected as quite high, say as certain probability to become infected if engaging in unprotected sex with a HIV-infected individual. As perception, it is natural to make *'Perceived risk'* as first order information delay of "incidents" expressing (or "informing" about) some risk:

'Perceived risk' = DELAYINF(Incidents,'Perception time',1,1 <<1/da>>)

the 3rd and 4th argument being the order of the delay and the initial value of the *'Perceived risk'*, respectively. The 2nd argument – *'Perception time'* – is a time constant defined as:

'Perception time' = 10 <<da>>

For the purpose of this paper we have defined *'Incidents'* as a series of pulses with decaying intensity. In other words, we assume that some stories in the media or hearing stories about people becoming HIV-infected are perceived as (less and less powerful) reminders of the HIV-threat.

The complete stock-and-flow model is shown on Figure 5.

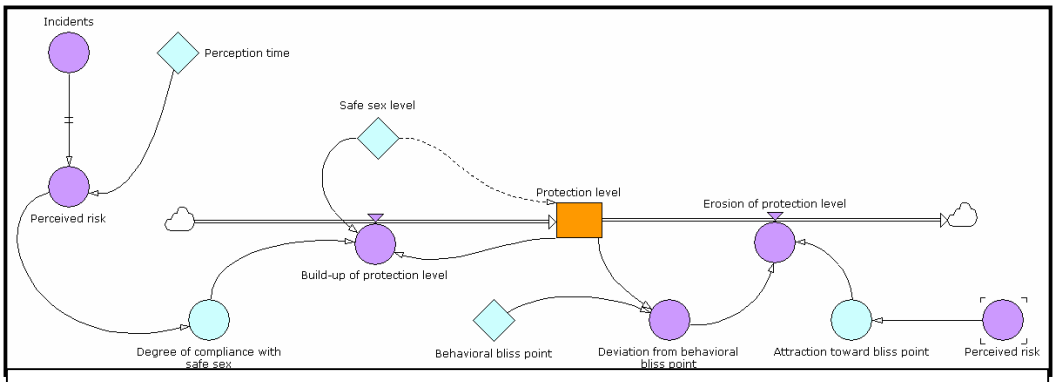

Figure 5 Stock-and-flow model. For details, see main text.

The model is not complex, implying that a few straightforward validation tests are quickly executed. E.g. if *'Degree of compliance with safe sex'* is constant and non-zero, whereas *'Attraction toward bliss point'* is constant and equals zero, then *'Protection level'* stays constant at 100% condom use; if *'Degree of compliance with safe sex'* is constant and has zero value, whereas if *'Attraction toward bliss point'* is constant and non-zero, then *'Protection level'* decays to 0% condom use.

The behavior of the model when *'Incidents'* is defined as above (p. 11) is shown on Figure 6:

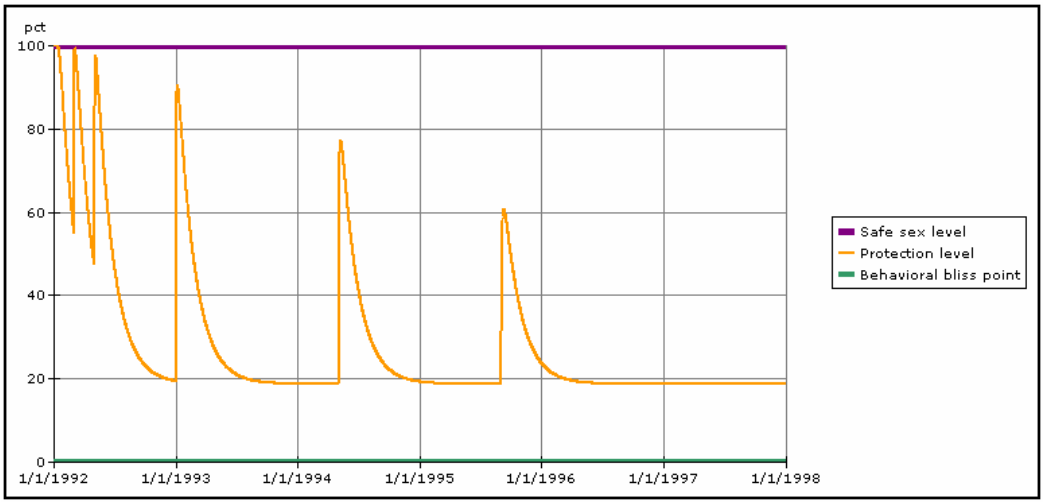

Figure 6 Starting with 100 pct condom use (*'Safe sex level'*) the subject's use of condom (*'Protection level'*) decays over time. A series of – weaker and weaker 'incidents' – cause transient increase of condom use until the frequency of condom use reaches asymptotically an equilibrium value between *'Safe sex level'* and 0% condom use (*'Behavioral bliss point'*). It is assumed that the subject does not become HIV-infected (or, if he is, that he is ignorant of his condition).

Policy Analysis

With all the caveats due to the high level of speculation involved in our model building, it is encouraging that the proposed mechanism based on behavioral regulation theory of instrumental conditioning and risk misperception seems to offer a conceptually simple and qualitatively satisfactory explanation of basic trends in safe sex practices.

Returning to the example of the teenager ("Kim") who spends little time doing school work whereas she devotes much more time to music (p. 7): Suppose her parents would consider as instrumental conditioning procedure to increase the amount of time Kim spends doing school work that she spends one minute doing school work for every minute she listens to music. Obviously, such procedure would only work if Kim's parents cared to enforce (or at least, to monitor) the instrumental contingency. According to the behavioral regulation theory of instrumental conditioning, instrumental conditioning procedures must constrain response options – otherwise they don't work. (Domjan 2000, Ch. 8)

Our explanation for the erosion of safe sex behavior suggests that the instrumental contingency is the perception of risk. In other words, if the perception of risk is realistic (i.e. HIV infection is a fatal disease, there is an unacceptable high probability to become infected through unprotected sexual intercourse in certain environments) then the instrumental contingency is operative. If risk is misperceived, one would have a situation similar to Kim's parents caring less and less to enforce the instrumental conditioning procedure. In such case, Kim would gradually decrease the amount of time devoted to school work and increase her time listening to music. In other words, Kim would perceive the instrumental contingency as weaker and weaker (the schedule line tilting to the left), and she would approach her behavioral bliss point as shown in Figure 7.

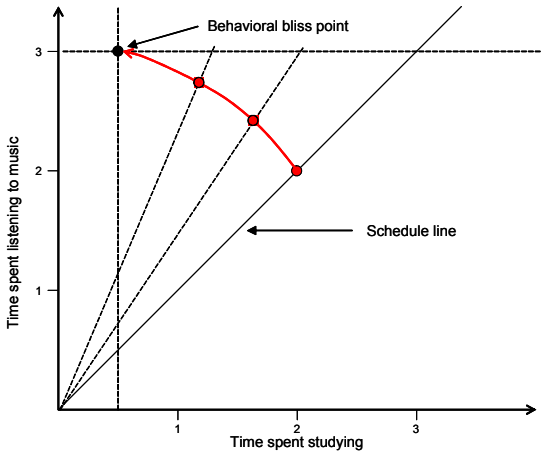

Figure 7 As Kim perceives that the instrumental contingency is loosely enforced she would gradually redistribute her activities until she is back at her behavioral bliss point.

Apart from the ephemeral effects of the incidents reminding the subject of the dangers of HIV infection, the trajectory of return to the bliss point on Figure 7 is pretty much the same as the erosion of safe sex practices as depicted on Figure 6.

It becomes clear that for safe sex procedures to work one needs a mechanism that sustains risk perception. If risk perception decays, so does safe sex.

An Intermezzo: Safety and Security Issues

In a parallel paper (Gonzalez 2002) we model the role of human factors in safety and security failures. There are strong reasons for this. Human factors play an essential role in both safety and security and, we will argue, they are largely shaped by the same determinants.

As field of study, safety is concerned with the aspect of prevention of disease, hurt, injury, or loss, mainly in the frame of risks from organizational accidents. Erosion of safe sex practices can be considered to be a particular case of erosion of safety awareness.

Security in the sense of computer or data security, has in mind measures to guard against espionage, sabotage and crime, the issues at stake being confidentiality, integrity and availability of data.

As a first approximation, the usual distinction between safety and of security in narrow sense is not crucial for the purpose of studying the role of human factors in the gradual erosion of standards. Our approach deals with security and safety procedures in terms of tasks, whose observance shape the actual risk level. Human factors are psychological mechanisms shaping observance or deviance from prescribed procedures as well as in perceptions of risk. In the case of safety issues, fortuitous events triggered by (mostly) unintended human actions and conditions (traffic e.g.) may or may not lead to an organizational accident – the probability for such an accident depending on the actual risk level. For security issues, the fortuitous events are triggered by intended human actions (malicious attacks) and conditions (traffic e.g.) – the probability for such a malicious attack to succeed depending again on the actual risk level.[10] Hence, at the general level of the causal interplay between human factors and technology, as described by abstract variables such as tasks, procedures, actual and perceived risk levels, stream of triggering events, etc, we may expect analogous models to be appropriate for both safety of technological contraptions and data security.

The causative space of organizational accidents, of other safety problems and of security issues is very rich. Among the human-related factors that might impair safety or security are throughput pressure or the shrinkage of allowable action as it occurs over the history of a given system (Reason 1990, 1997); "behavioral economics" (Battmann and Klumb 1993); etc.

However, we would like to argue that a mechanism based on behavioral regulation theory of instrumental conditioning and risk misperception, analogous to the one presented in this paper for erosion of safe sex practices, should be considered a fundamental explanation for the general case of safety or security. Indeed, such hypothesis would conform to basic facts of human character (propensity to misperceive risk, biological roots of instrumental conditioning) and the proposed mechanism would always be operative, whereas other proposed causes might be

[10] Consideration of malicious attacks has not been as central for the field of safety as it traditionally has been for security, but the increasing threat of terrorism makes this aspect more and more relevant for safety, too.

absent. In fact, the erosion of security awareness is easily observed among computer-addicted teenagers in the absence of throughput pressure and "economic" factors.

Our claim should not be misunderstood: We are not pretending that a mechanism based on behavioral regulation theory of instrumental conditioning and risk misperception would do full justice to the highly complex field of safety or security. To quote Benzon (Benzon 2001, p. 3) once more: "Our experience is complex and so requires complex explanations. Any act or experience lies at the nexus of many causal threads, each one of which must be followed if we are to understand that experience." Rather, our claim is to the ubiquitousness of the proposed mechanism: Misperception of risk and instrumental conditioning are so-to-speak parts of human nature and we cannot shed them off. Moreover, their working is in the depths of the unconscious and, hence, to a high degree out of reach for our control. In the absence of counterforces, they shape our perceptions and actions.

A Proposed Experiment

There is another good reason for enlarging the scope to consider safe sex practices in the context of general safety and security issues: Such vision makes it possible to indirectly test the proposed mechanism based on behavioral regulation theory of instrumental conditioning and risk misperception.

Our studies of safety and security issues[11] employ experiments in microworlds (developed with Microsoft Visual Studio in cooperation with a company working on system security). I.e., subjects make decisions in simulated environments that affect the security or the safety of the system. The aim of such experiments is to collect relevant data, distill reference behavior modes, generate dynamic hypotheses for the role of human factors in safety and security failures and ultimately to develop better policies for reducing human failures.

Among the studies we are designing is an experiment to test aspects of the proposed mechanism. In the experiment subjects carry out tasks for some purpose (i.e. registering sensitive patient data) in an environment that is susceptible of malicious attacks – though with a low probability (to allow risk perception to decay as a consequence of "non-events"). The experiment would be carried out with two groups: (1) A control group, and (2) a group regularly receiving reminders and information about potential risks.[12] In other words, for group (1) the instrumental contingency would wither away, whereas for group (2) one would aim at sustaining the instrumental contingency and hopefully confirming that – indeed –compliance with security regulations would stay at a high level.

Potential policies

Assuming that the proposed experiment does indeed confirm that realistic risk perception is the crux of the matter – so-to-speak the instrumental contingency itself – the following two policies should be worth of further consideration:

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[11] These studies are done jointly with Agata Sawicka, Agder University College, among others.

[12] This is a very simplified version of the experimental setup, of course. Among various important issues, we mention that figuring out the type, extent and frequency of information about potential risks to be given would be an essential aspect of the study.

1. Counteracting misperception of risk through appropriate reminders and information about risk.
2. 'Social proof' – "What most people do is right" (Cialdini 1993).

Policy (1) would be a practical application of the proposed experiment – provided the experiments confirm our hypothesis.
Policy (2) would try to employ the strong forces of persuasion associated with group patterns. For this to work, one would need a reference group successfully sustaining safe sex practices and make their behavior known for the groups to be influenced.[13]

Our work is still incipient and much remains to be done.

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[13] Policy (2) and (1) could be combined, of course.

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