

PRESSURE AND TRUST IN COMPETITIVE ENGINEERING

Udo Pulm¹ and Ralf Stetter²

(1) BMW AG, Germany (2) Hochschule Ravensburg-Weingarten, Germany

ABSTRACT

In competitive engineering the term “pressure” is used frequently. Design engineers often face time pressure or cost pressure. Pressure can be described in design engineering as activities of individuals or groups which are intended to fasten or change the behavior of other individuals or groups, i.e. mainly to increase the workload one has to accomplish. Pressure can be either an incitement or an abashment. In sports research, pressure has been identified as a major influencing factor since several years and has been researched intensively [1], [2], [3]. In design research a recent focus has been on trust [4] and emotional alignment in teams [5]. Trust seems to be core to developing and maintaining a successful relationship. Trust is a main prerequisite for knowledge sharing in collaborative design; extensive pressure seems to hinder knowledge sharing and communication. This paper presents and explains the hypothesis that pressure and trust are two main influences on collaborative design productivity and that the functions and consequences of both can only be fully understood if they are considered simultaneously. The paper is based on an extensive literature review, a retrospective analysis of two design engineers, logical reasoning, and numerous discussions with colleagues in practice and academia.

Keywords: Pressure, Trust, Product Development Processes, Knowledge, Innovation

1 LITERATURE REVIEW

Several publications have been looking into the acting and thinking of design engineers in product development processes [6], [7], [8], [9], [10], [11], [12]. In this endeavor also group and social processes were analyzed [13], [14], [15], [16]. Several researchers have recognized that design is a social process [17], [18]. Recent publications also identify conflict as a possible source for innovation [19], [20]. Research concerning cooperative product development is concentrating on trust [4], interpersonal relationships [21], shared understanding [22], [23] and emotional alignment [5]. First publications in the field of product development look specifically into pressure; the main focus is on time pressure [24], [25], [26], [27], [28]. In sports research, pressure has been identified as a major influencing factor since several years and has been researched intensively [1], [2], [3]. The functions and consequences of pressure in product development were discussed in [29], [30].

2 RESEARCH METHOD

The conclusions presented in this paper are based on a retrospective analysis of actively participating individuals, an extensive literature review, and logical deduction. Actively participating individuals are understood as persons who are an integral part of the organization and who carry their own responsibilities for a part of the company core processes. In design research, the merit of participant observation is generally agreed upon. Very often, participant observation is carried out by design engineers who primarily work as design researchers. These participants were able and will be able to investigate interesting characteristics of design. However, some phenomena are hidden to such individuals. The situation in the research society in Germany is a bit different. Design researchers in Germany are typically mechanical designers who research design during their dissertation. Later on, they participate in the processes which they analyzed before as design engineers or product development managers. The two authors followed this common route. Through numerous discussions with design engineers and product development managers who share the same background the authors found that research methods which can be performed by persons outside or at the fringes of an

organization such as non-intrusive observations, protocol studies, interviews, and (non-active) participant observation are appropriate to investigate design but that the underlying causes for many decisions, emotions, processes, failure, etc. are hidden to those ‘outsiders’ who cannot know the ‘historical’ background and have no deeper insight into the personality of the individuals. Very often researchers are not allowed to attend the decisive meetings, frequently ‘historical’ backgrounds and other facts are not communicated to them or are communicated wrongly as a consequence of shame or ignorance. This discussion is not intended to question the merit of such investigation methods. Such methods have given extremely interesting and valid insights into the nature of design and are the only possibility if quantitative results are sought for. However, the authors argue that in the case of qualitative, exploratory research a retrospective analysis of participating individuals can help to investigate the underlying causes and complicated phenomena such as pressure and trust. The limitations of this investigation method are the limited capabilities of human beings to remember correctly and the possibility that memories are unconsciously adapted to concepts of current interest. Still, when researchers explicitly consider these points and discuss their memory of the experience with others, valuable insights can be found which contribute to a better understanding of design and product development as it happens in industrial practice. Accordingly, the results presented in this paper, which are results of a retrospective analysis of actively participating individuals, an extensive literature review, and logical deduction, should be weighted as results of qualitative, exploratory research.

3 PRESSURE

In this section, a definition of “pressure” in product development is attempted. Baumeister&Showers [1] define “pressure” in sports as the presence of situational incentives for optimal, maximal, or superior performance. Similarly, pressure can be defined “as a situation in which a person perceives something being at stake depending on the outcome on one’s performance” [2]. In product development pressure can be understood as all activities of individuals and organizations that are intended to make other individuals or the regarded or another organization change their behavior against an original intension, to accelerate the behavior, or to increase the workload quantitatively or qualitatively. The objective of pressure is frequently to raise the performance in the sense of work in a certain time unit (including result quality). The central meaning is therefore interference by means of extrinsic motivation. Usually pressure is applied only by means of psychological forces.

3.1 Functions of Pressure

This section explores the underlying causes of pressure, i. e. which goals pursue individuals who apply pressure. The justification to apply pressure in industrial product development processes is usually the actual or sensed enforcement to solve additional tasks and get more results, i.e. to accomplish a bigger workload under the condition of limited resources.

The most obvious objective for this is an optimization of the profit or – formulated less critically – more competitiveness as a necessity in order to survive in the market. More immediate objectives result from personal reasons of the person who applies pressure, e.g. striving for power or career within internal competition. Frequently immediate objectives arise from the social group dynamics, i.e., from the need of individuals to take their unique position in a social group. On the personal level, pressure is also used in order to compensate for personal deficiencies, such as giving unclear targets and decisions, the inability to plan or accomplish a project, lacking resources, etc. Thus, pressure might also arise from the lack of competencies in certain areas of a company and, as pressure does, spread around and influence other parts of the company, too.

A number of indirect, yet important objectives can be identified, which support the immediate objectives and can be understood as the functions of pressure. Nevertheless, these functions of pressure do not seem to be always intended consciously:

- Pressure is applied in order to raise the efficiency and effectiveness.
- Pressure can be used to accomplish changes of the organizational structure (e.g. process revolution).
- Pressure can be used to force individuals to use methods and tools.
- Pressure can be used to force individuals, who prefer perfect solutions, to generate pragmatic, economical solutions.
- Pressure can be used to avoid unnecessary process sections and by this to achieve economical

processes.

- Pressure can be used for the orientation towards a common goal and by this to direct the process.
- Pressure enables people to make decisions – even unpopular decisions – and stick to those decisions; or skip them if the boundary conditions have changed.
- Pressure can be used to force individuals in a company to acquire new knowledge or capabilities.
- Pressure can be understood as a measure to assess the quality of the product development process.

3.2 Diffusion of Pressure

One of the main reasons why and principles how pressure is spread and diffused is that a person under pressure, which means that he/she has a big workload, will try to delegate parts of his workload to other persons, which themselves might be on the border of pressure concerning workload. This happens either to accomplish the tasks at all, which alone could be impossible, or due to a feeling of injustice, i.e. that others should get some of the work, too.

Another more subtle reason and principle is that work cannot be done perfectly anymore, that a person under pressure can hardly consider the demands of others, that there is hardly any coordination so that work is done double, that results are hardly documented, communicated, and achieved only late, etc. This all will lead to the fact that another person's work is aggravated, leading again to more pressure.

Pressure also seems to be contagious. If one person has to work under pressure, other persons feel pressurised, too, in the meaning that they do not want to appear as "lazybones". But being under pressure or seeing supervisors use pressure also leads to the attitude that pressure is the right thing to use; the person under pressure feels his right to put others under pressure. This can lead to a culture of pressure in the organisation, which cannot be escaped easily. This spreading of pressure can become a vicious circle, leading to more and more pressure. The experience that pressure has helped in the past to overcome critical situations or to get the desired results will strengthen the opinion that pressure is the right way to drive an organisation and, again, finally tighten the culture of pressure.

Pressure can also lead to a lack of time for reflection of the processes, use of methods and tools, etc., which should improve the efficiency of the process or the organisation and reduce pressure. The continuous "fire fighting" again is a vicious circle of chaotic work, not allowing a systematic approach if people only think in the short term. Pressure also obstructs making clear decisions or elaborating the bases for clear decisions, which again will lead to more pressure.

The diffusion of pressure permits that pressure does not have to be put on every individual element of a system. Pressure inflicted in one or few places will spread through the system and put the whole system under pressure. This will lead to the fact that the system has to cope with the pressure itself, it has to self-organise its pressure and thus its organisation. This and other consequences of pressure will be discussed in the next section.

3.3 Consequences of Pressure

The consequences of pressure in cooperative product development are naturally identical to the functions of pressure, such as efficiency, pragmatism, and focus on the most important parts of work, use of methods, process optimization, and self-organization. Of course they are also identical to the aspects described in the consideration of the diffusion of pressure, as there are imperfect, lacking, or late outcomes, lacking use of methods, lacking communication or decisions, or an increase of administrative activities, i.e. that organizational activities on the individual level exceed operational activities. The consequences might also be that administrative, process oriented activities completely recede for the benefit of operational activities. This contradiction shows that pressure can have contradictory effects, depending on its extension in a certain situation. Additionally, pressure has consequences on the individual level. These cover discontentment, stress, illness, depression, demotivation, and horizontal or vertical escape mechanisms (working on other things than actually needed or merely planning what and how to work). Of course pressure on the own person is possibly desired by certain people, who otherwise would suffer boredom, would feel unchallenged, or need it as a form of motivation, feedback, integration, and identification with the organization, direction or focus and a way to prove themselves. Lacking pressure in this context can force employees to leave the organization. On this organizational level, pressure will thus help screening highly capable persons for management or the company itself. To which extent this is an adequate approach has to be discussed (the alternative would be to develop each employee and use him according to his capabilities).

Pressure also shows effects on the technical side. Pressure on the organization might lead to less innovation, less perfect solutions, and less trial on new products and technologies. Unfortunately, market pressure mainly diffuses in terms of cost and time, the pressure on quality often recedes compared to those due to inadequate demands on quality. But when failures occur – leading to call-backs of products – cost and finally the pressure in the organization increase again.

3.4 Generation of Pressure

The previous sections have described the deeper purpose and the consequences of pressure in product development. We now have to consider how pressure is generated practically. Generally, we have to distinguish between directed and undirected pressure, i.e. that a certain target has to be achieved or that the efficiency generally has to be increased, as well as between beneficial and obstructive pressure. Positive pressure can be achieved by demanding clear and meaningful results with a tangible outcome and by giving close but realistic deadlines. At this point it has to be mentioned that pressure is also linked to risk or risky solutions; the higher the risk, the higher the pressure. It is also a way to reduce (too high) pressure by going back to less risky solutions or to have a save fall-back solution.

Positive pressure is also generated by posting clear rewards for and recognition of the work done. Pressure in a self-motivating sense can also be realized by the clear and total assignment of the responsibility for a task, also allowing identification with the outcome and considering interests in the job. Pressure can also be applied by pure management attention; e.g. a simple and single “You care for the project?” thrown in a small talk by the superior can have marvelous effects.

Pressure as a psychological issue is furthermore strongly connected to emotions. Showing emotions in a positive way, in the meaning of enthusiasm as well as concern for the targets of the company, can lead to positive pressure. This presumes that the individual targets are in line with the company targets and that the “pressing” supervisor acts as an ideal role model. Thus, positive pressure can also be built up by giving an example, i.e. people will work harder if colleagues or the supervisor also work under pressure, without moaning and just delegating the pressure.

Pressure can also result from negative behavior, which is closely related to de-motivation. Such behavior might be caused by inattentiveness, but it might have its cause in other, political or personal reasons. The causes of such negative pressure can be disinterest of the superiors, differences in appointments and personal values, contradicting tasks, injustice, insults, personal attacks, unclear tasks and deadlines, lacking appreciation of one’s work, lacking trust combined with too much control, lacking delegation of responsibility, isolation from the group, the product, or the core process, not comprehensible decisions, decisions that object the groups opinion, the refusal to reason decisions, tasks, deadlines, etc., or a general atmosphere of disinformation. The pressure arises when an affected person strives more and more to get attention, justice, trust, etc. This might refer to more and better work on the product itself or to an additional mental work on the social level, i.e. trying to solve the problems itself, or the inner level, i.e. thinking about the inadequacy of the situation and how to solve it. At first, of course such behavior is wrong, but it could be argued that in certain situations even such behavior is appropriate in the meaning of contradictory or paradox or pathological influencing of others, i.e. in order to force them to change their behavior or attitude. But especially in this case it is important to use it sensible and consciously.

A special case of pressure emerges through additional formal activities and thus is a mixture of the previously discussed aspects. Additional work here refers to administrative activities such as using certain tools, documenting, writing requests, preparing presentations, etc. Such activities are necessary in complex organizations, so that they are not only appointed by a superior, but also emerge from the process. The additional activities also refer to the social interaction, career work, education, etc. It is a tightrope walk between implementing or accomplishing such activities in order to reduce the workload and thus the pressure in the long run, and reducing such activities where possible.

Finally, there is a prerequisite to the generation of pressure, which is that not reacting to the pressure will have negative effects. These sanctions might be reduction of payment or even loss of the job, personal warnings or scolding, social disapproval, or the withholding of promotions.

4 Trust

Cloonan et al. [4] understand trust to be a willingness to rely on another party in the confidence that this reliance will provide a positive outcome. The trustors who share knowledge make themselves vulnerable in that they expect that their interests will not be threatened. It can be hypothesized that this

readiness is endangered by high pressure in an organization. The most important concepts to understand trust are the distinction between conditional and unconditional trust as well as the distinction between interpersonal trust and institutional trust. The distinction between conditional and unconditional trust frequently relates with the lifecycle of a relationship. At the start trust is given conditionally, as both parties in the relationship are willing to work with each other [31]. As the relationship matures, individuals become more comfortable with other team members and the level of trust becomes unconditional. Interpersonal trust refers to trust between people and system or institutional trust refers to trust in the functioning of organizational, institutional, and social systems [32], [33]. The emergence of trust is also seen in connection with a positive surprise regarding the expectations in another person's behavior, i.e. that a person does more than is expected from him. Abrams et al. [34] establish connections between trust and knowledge sharing. They deduce "trustworthy behaviors" that can help managers to promote trust in their organizations. Examples include acting with discretion, ensuring a shared vision, enabling personal connections and ensuring that decisions are fair and transparent.

4.1 Functions of Trust

As organizations have come to rely less on structures and formal arrangements and more on collaboration and cooperation inside and outside the firm, new emphasis is given on trust as one of the fundamental motors of these processes [32]. Of course, in large organizations such structures, rules and processes have to be established in order to coordinate the complexity of such systems. But experience has shown that such processes do not work effectively, if trust is absent. On the other hand, a large organization based on trust and collaborative work without processes will lead to uncoordinated and as well ineffective work. The balance between a trust-based and a process-based organization has to be kept in mind and should be discussed more deeply. But they should not be understood as contradictions; trust is the basis for good processes as well as well-defined – and understood – processes can facilitate the generation of trust.

Nevertheless, if trust is absent, no one will risk moving first and all will sacrifice the gains of collaboration and cooperation. The benefits of trust can be found in a reduction of transaction costs, collaboration and cooperation within and between organizations, and effects on performance and effectiveness. Trust has been associated with positive work attitudes and behaviors such as open communication and information exchange, acceptance of influence, reduction of conflict, citizenship behavior, commitment, and satisfaction. Trust has also been associated with the ability to enhance collaboration and mutual learning between individuals by leading to cooperation and higher individual and team performance. To conclude, the main function of trust in product development is achieving a shared understanding and therefore an enhanced effectiveness and efficiency.

4.2 Diffusion of Trust

The same as pressure, trust can spread over an organization and become a cultural aspect of that organization. Trust seems to be contagious. If somebody trusts you, it is natural that you trust that person, too. Also, if there is a culture of trust, i.e. somebody sees that everybody trusts each other, it is easy to also trust others and you will try to be trustworthy, too. In this way, trust is also contagious: If somebody trusts you, normally you will try to fulfill this trust. Trust in this sense means open communication, the fulfillment of expectations, an open dealing with failures, reasoning of decisions, support, realistic targets and workloads, etc. Again, trust can become a vicious circle and it is a social phenomenon that no one wants to stand outside a social system.

4.3 Consequences of Trust

According to Ichijo et al. [35] trust improves the quality of dialogue and discussions and encourages knowledge sharing. The main consequence of trust in product development is a shared understanding concerning the product, the process as well as the organization and even certain characteristics of individuals. This shared understanding can streamline communication processes or even render them unnecessary. One intermediate consequence of trust can consequently be an enhanced effectiveness and efficiency of product development processes in concurrent engineering. However, trust is not appropriate as a main indicator of performance, since design tasks require specific abilities and knowledge to be adequately performed [32]. In situations where individuals or teams do not possess adequate skills and knowledge to successfully accomplish their tasks, trust probably will not improve

performance. Under certain conditions trust may play a more a moderated role by facilitating communication and openness, which can lead to the exchange of important knowledge or generate critical discussions that may be beneficiary for the end product.

4.4 Developing and Maintaining Trust

Trust develops over time and goes through various phases such as building, declining, or renewal. Three bases for developing trust in work relationships have been identified [32]:

- Calculus-based trust: this form of trust is likely to be found in relationships that are new, and are formed between partners or team members who do not have any prior social connections. Trust is based on calculation of the benefits of being trusting and trustworthy against the threat that, if trust is violated, one's reputation may be damaged by the other person(s) network of friends or colleagues.
- Knowledge-based trust: this form of trust is based on prior interactions and cooperation. It occurs when one has enough information about others to understand them and be able to predict their likely behavior. This again refers to the emergence of trust through a positive surprise regarding the expectations in one's behavior.
- Identification-based trust: this form of trust is based on identification with the other party's desires and intentions. This form of trust arises between people who share a common identity, meaning that they hold similar values, including a shared concept of moral obligation. Here, trust develops through empathy because the parties effectively understand and appreciate each other's wants; this mutual understanding is developed to the point that each can effectively act for the other.

The differentiation between calculus-based trust and knowledge-based trust suggests a differentiation between "felt" trust and "acted" trust. Somebody might not trust others completely, but act trustfully in order to start the generation of open communication and trust. Or he might trust other persons, but due to critical circumstances does not act trustfully, e.g. in the meaning of control and fall-back solutions.

Von Krogh et al. [36] recommend a number of steps to create trust. One particular recommendation is about sharing personal information within the context of smaller groups. The argument is that sharing personal information increases interpersonal trust which in turn encourages information sharing. It then becomes a virtuous circle of sharing information through unconditional trust.

Abrams et al. [34] launched ten 'trust-builders' as behaviors that promote interpersonal trust. These trust-builders are:

- Ensure frequent and rich communication;
- Engage in collaborative communication;
- Create personal connections;
- Establish and ensure shared vision and language;
- Give away something of value;
- Act with discretion;
- Be consistent between word and deed;
- Ensure that decisions are fair and transparent;
- Hold people accountable for trust;
- Disclose your expertise and limitations.

These "trust-builders" combined with a knowledge about the bases for developing trust may enable design engineering managers to consciously influence the development and maintaining of trust; however it is a central hypothesis of this paper that only the right combination of trust and positive pressure will lead to effective und efficient processes in product development. The strong connection between trust and pressure can be seen in the fact that a reduction of the above mentioned aspects are considered as causes for negative pressure. This combination is discussed in the next section.

5 PRESSURE AND TRUST

Pressure and trust in competitive engineering share one main function – to increase the effectiveness and efficiency of the processes. For pressure it has been found that an optimum point of pressure is existing [29]. In general, at least theoretical considering its objectives, pressure increases the efficiency and thus the performance and the outcome of an organization, either quantitatively or

qualitatively. This is valid up to a certain degree, from which the performance again decreases (Figure 1).

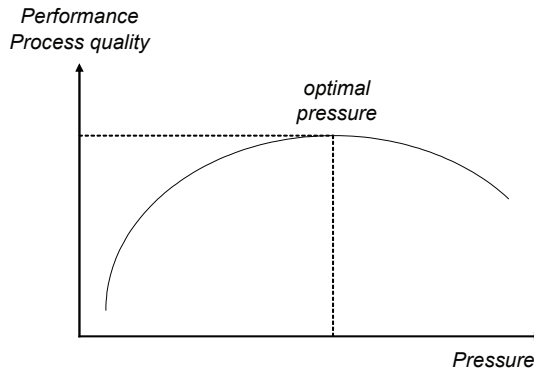


Figure 1. Relation of Performance/Process Quality and Pressure

The reasons for that are e.g. increase of administrative activities, escape behavior, depressions, sickness, individual performance needed for self-preservation, defense mechanisms against the pressure, frustration, coordination efforts, fire-fighting activities, and chaotic behavior.

If one is analyzing this problem superficially, he/she might conclude that pressure is opposed to trust. People under pressure will focus on their own problems and work. This can lead to less communication within the organization, through which problems can occur. This again will decrease trust in the company. This leads to a first hypothesis of this paper:

Hypothesis 1: A high amount of pressure can prevent or decrease trust.

The example of high-pressure teams, e. g. fire-fighters opposes this view. Such teams are under very high pressure (the necessity to risk their lives) however the trust in such teams is apparent and necessary. This leads to a main hypothesis of this paper:

Hypothesis 2: Pressure does not necessarily prevent trust.

It can be argued that outside pressure, which afflicts a system or a team as one, can create trust within that system or team, as there is one common “enemy”. Pressure generated within a system or a team or between teams will decrease trust, since the pressure-generators are considered as “enemies”.

For product development managers responsible for processes which are effective and efficient on a sustainable level one main question can be derived:

Question: How can a sensible amount of pressure be achieved without risking trust?

The apparent answer is to always consider pressure and trust in parallel. When analyzing high pressure/high trust teams such as fire-fighters it becomes apparent that the causes for pressure (the fire) are usually not results of activities of members of the group. The underlying causes for pressure are external and all members of the team are aware of this fact. Thus, when pressure emerges, it is necessary to build up identification as one team, organization, or system. This leads to a first conclusion:

Conclusion: Trust is less endangered by pressure if the underlying causes of pressure are external causes (such as market pressure, recession, etc.) and if the connection between the external causes and the internal pressure is openly discussed.

In many product development departments designers are willing to work overtime and to utilize their time as good as possible, if they observe that their superiors are also struggling as hard to achieve common goals; the “pressing” superiors act as ideal role models.

Conclusion: Trust is less endangered by pressure if superiors are subjected to the same consequences of pressure as their inferiors.

Slovic [37] found that trust is typically created rather slowly, but it can be destroyed in an instant by a single mishap or mistake. The creation of trust is possible if team members are able to keep their promises towards other team members or also external individuals. In industrial product development departments it can frequently be observed that superiors make decisions that force subordinates to break their promises. Such situations are critical as lost trust is very hard to win back. Trust can be developed only in case superiors in the organization allow their subordinates reliability. Especially intermediate managers or coordinators will only be able to be trustworthy if they are allowed to keep their promises.

Conclusion: Trust is endangered if superiors make decisions that generate pressure and force their subordinates to break their promises towards team members.

As mentioned above, positive pressure can be achieved by demanding clear and meaningful results with a tangible outcome and by giving close but realistic deadlines. This insight can also be explained by the effect on the trust. Trust can be build in an environment where subordinates observe that clear objectives are set and that they can meet the set objectives.

Conclusion: Trust is less endangered if objectives are consciously set and if set objectives are realistic.

Additionally, positive pressure is also generated by posting clear rewards and recognition for and of the work done. Subordinates generally want to be able to trust their superiors that their engagement will result in positive feedback.

Conclusion: Trust is less endangered if clear rewards are announced and are given accordingly.

Pressure in a self-motivating sense can also be realized by the clear and total assignment of the responsibility for a task. Designers who carry a responsibility for parts of the product to be developed can more easily exhibit trustworthiness as designers which are only assigned single tasks. As trust needs to be developed, individuals must have some instances of freedom to show actions which underline their trustworthiness. For superiors, this means also allowing identification with the outcome of and considering interests in the job.

Conclusion: Trust is less endangered if a larger share of responsibility for demanding tasks is given to subordinates.

Pressure can be reduced by aspects such as an open dealing with failures (that they are not just punished), fall-back solutions, a clear understanding of risks (risky solutions), etc. These aspects seem to support trust in the same way.

Conclusion: Trust is less endangered if measures are applied in order to reduce pressure.

As concluded in Pulm&Stetter [29] the causes of negative pressure can be disinterest of the superiors, differences in appointments and personal values, contradicting tasks, injustice, insults, personal attacks, unclear tasks and deadlines, lacking appreciation of one’s work, lacking trust combined with too much control, lacking delegation of responsibility, isolation from the group, the product, or the core process, not comprehensible decisions, decisions that object the groups opinion, the refusal to reason decisions, tasks, deadlines, etc., or a general atmosphere of disinformation. When these items

are compared to the trust-builders according to Abrams et al. [34] listed in Section 4.3 it becomes apparent that they are nearly opposed. This leads to one general proposition:

Conclusion: Trust is endangered if negative pressure is applied.

As mentioned above, a special case of pressure emerges through additional formal activities. Additional work here refers to administrative activities such as using certain tools, documenting, writing requests, preparing presentations, etc. Looking at these activities with the focus on trustworthiness it becomes apparent that many of these activities can be understood as monitoring activities. According to Costa [32] perceived monitoring usually has a negative effect on the generation of trust.

Conclusion: Trust is endangered if the share of formal activities in the organization is large, as designers may experience this as monitoring and distrust.

Additionally, in literature it is frequently elucidated that trust requires an abandonment of control [38]. Superiors need to abandon measures as close surveillance, close control of intermediate results, monitoring of time spent, etc. Subordinates may understand any monitoring as a form of control and consequently as a form of distrust.

Conclusion: Superiors need to abandon control at least partly, i.e. they need to refrain from excessive monitoring, in order to avoid a feeling of distrust.

It is important to note that monitoring will not necessarily lead to distrust. Subordinates may understand – if they are willing to do so – that managers need to establish certain control systems or install fall-back solutions not as a matter of distrust but for general strategic considerations. Subordinates may still feel a level of trust if they perceive the control as focused on other subordinates or on clear targets.

When reviewing the core points of the discussion above, a core element becomes apparent: the most important factors which can help to build trust are accessible by logical deduction and are not alien to design engineers and their managers. However, in many industrial companies design engineers and managers would not accept the importance and necessity of trust.

Conclusion: Superiors and subordinates need to realize that trust is a prominent prerequisite for efficient and effective processes.

Figure 2 summarizes the conclusions listed above.

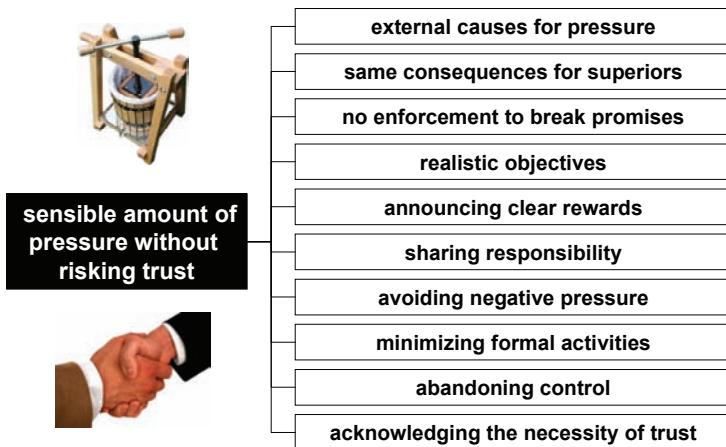


Figure 2. Achieving a sensible amount of pressure without risking trust

The discussion of pressure of trust exhibits a rather complicated relationship between these two notions. Some aspects of this relationship are shown in figure 3.

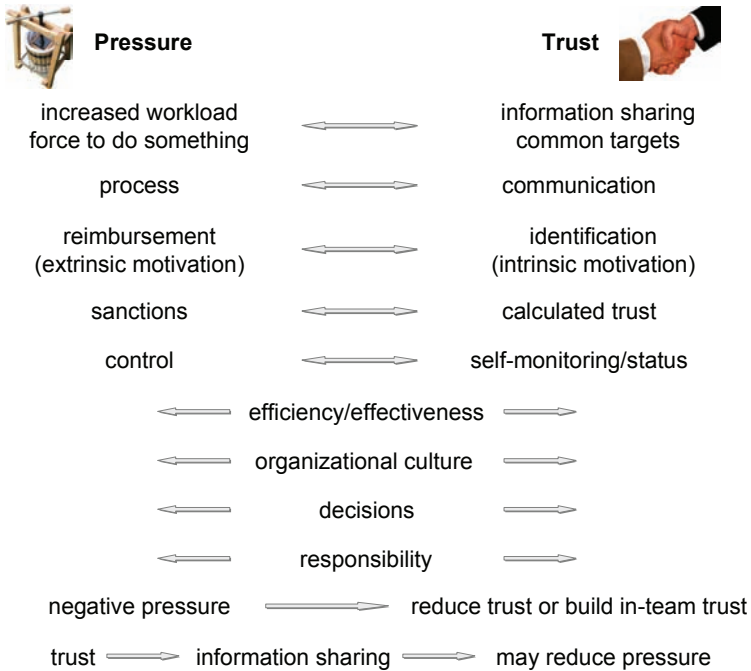


Figure 3. The complicated relationship between pressure and trust

The core objective of pressure is frequently the existing or perceived necessity to cope with an increased workload, whereas the core effect of trust is to allow information sharing. If pressure is understood as a means to drive a product development department in a certain direction the strong connection to the process becomes apparent; whereas the basis for trust is usually build on communication. Pressure is focused on extrinsic motivation, whereas trust is focused on intrinsic motivation. Under pressure designers may work in a more efficient manner because they are afraid of sanctions, whereas calculated trust may achieve the same results in terms of process improvement. Both pressure and trust can be a means to increase efficiency and effectiveness, both strongly influence the organizational culture, both strongly influence decisions, and both assign and influence responsibility. As causal relationships it can be concluded that negative pressure will reduce trust or, at least, will result in build in-team trust, which can be found in high pressure teams such as fire-fighters. Trust will lead to more information sharing and as a consequence of this effect may contribute to a reduction of pressure.

6 SUMMARY

Pressure and trust are important factors influencing design process effectiveness and efficiency. Trust is a necessary prerequisite for knowledge sharing; pressure can reach an optimum level regarding the design process effectiveness and efficiency. It is a central hypothesis of this paper that only the right combination of trust and positive pressure will lead to effective und efficient processes in product development. The two concepts influence each other but are neither concurring nor opposed. The main hypothesis which was elaborated in this paper is: "Pressure does not necessarily prevent trust". Furthermore, it was elucidated that one central question for product development managers can be stated as: "How can a sensible amount of pressure be achieved without risking trust". In the paper first approaches to achieve a sensible amount of pressure are listed as answers to this question. The main conclusion of this paper is, that when pressure is applied, trust has to be regarded, too. Pressure and trust always have to be considered in parallel. Further interdisciplinary research is needed to support

the presented conclusions; meanwhile design engineering managers may use them as hints towards more effective and efficient processes on a sustainable basis.

REFERENCES

- [1] Baumeister, R.F., & Showers, C.J. (1986). A review of paradoxical performance effects: Choking under pressure in sports and mental tests. *Journal of Social Psychology*, 16, 361-383.
- [2] Ehrlenspiel, F.: Choking under Pressure – Attention and Motor Control in Performance Situations. Dissertation Universität Potsdam. Potsdam: 2006.
- [3] Oberländer, A., Ehrlenspiel, F. & Erlacher, D. (2006). Versagen unter Druck - Ein Phänomen der Knotenpunktkontrolle? In B. Halberschmidt & B. Strauß (Eds.), *Elf Freunde sollt ihr sein!?* 38. Jahrestagung der Arbeitsgemeinschaft für Sportpsychologie (ASP) gemeinsam mit dem Bundesinstitut für Sportwissenschaft vom 25. bis 27. Mai 2006 in Münster (S. 110). Hamburg: Czwalina.
- [4] Cloonan, J.; Matheus, T.; Sellini, F.: The Impact Of Trust And Power On Knowledge Sharing In Design Projects: Some Empirical Evidence From The Aerospace Industry. In: *Proceedings of the International Design Conference DESIGN, Dubrovnik, 2008.*
- [5] de Boer R.J. and Badke-Schaub P.: Emotional Alignment In Teams: How Emotions Support The Design Process. In: *Proceedings of the International Design Conference DESIGN, Dubrovnik, 2008.*
- [6] Dylla, N.: *Denk- und Handlungsabläufe beim Konstruieren.* München: Hanser 1991. München: TU, Dissertation, 1991.
- [7] Fricke, G.: *Konstruieren als flexibler Problemlöseprozeß – Empirische Untersuchung über erfolgreiche Strategien und methodische Vorgehensweisen beim Konstruieren.* Düsseldorf: VDI, 1993.
- [8] Günther, J.: *Individuelle Einflüsse auf den Konstruktionsprozeß.* Aachen: Shaker 1998.
- [9] Minnemann, S.: *The Social Construction of a Technical Reality: Empirical Studies of Group Engineering Practice.* Palo Alto: Stanford University, Ph. D. thesis, 1991.
- [10] Rutz, A.: *Konstruieren als gedanklicher Prozeß.* München: TU, Diss. 1985.
- [11] Stauffer, L.; Ullman, D.: A comparison of the results of empirical studies into the mechanical design process. In: *Design Studies* 9 (1988) 2 pp. 107-114.
- [12] Tang, J.: *Listening, Drawing, and Gesturing in design: A Study of the Use of Shared Workspaces by Design Teams.* Palo Alto: Stanford University, 1989.
- [13] Frankenberger, E.: *Arbeitsteilige Produktentwicklung – Empirische Untersuchung und Empfehlungen zur Gruppenarbeit in der Konstruktion.* Darmstadt: TH, Dissertation, 1997.
- [14] Lauche, K.: *Measuring Social Skills.* In: Bocquet, Jean-Claude (Editor): *Knowledge, Innovation and Sustainability. Proceedings of the 16th International Conference on Engineering Design.* Paris: Design Society, 2007.
- [15] Minnemann, S.; Harrison, S.: *Negotiating Right Along. An Extended Case Study of the Social Activity of Engineering De-sign.* In: Duffy, A. (Ed.) *The Design Productivity Debate.* Springer: London, 1998, pp. 32-50.
- [16] Stetter, R.; Ullman, D.: *Team-Roles in Mechanical Design.* In: McCarthy, J. (Ed.): *Proceedings of the ASME 1996 Design Engineering Technical Conferences and Computers in Engineering Conference.* Irvine: ASME International, 1996, CD-ROM.
- [17] Bucciarelli, L.L., *Designing Engineers,* The MIT press, Cambridge, Massachusetts, 1994.
- [18] Cross, N.; Clayburn Cross, A.: *Observations of teamwork and social processes in design,* *Design Studies*, 16, 1995, 145-170.
- [19] Badke-Schaub, P.; Goldschmidt, G.; Meijer, M.: *Cognitive Conflict in Design Teams: Competing Or Collaborating?* In: Bocquet, Jean-Claude (Editor): *Knowledge, Innovation and Sustainability. Proceedings of the 16th International Conference on Engineering Design.* Paris: Design Society, 2007.
- [20] Jehn K.A.; Mannix E. *The dynamic nature of conflict: a longitudinal study of intragroup conflict and group performance.* *Academy of Management Journal*, 2001, Vol. 44, p.p.238-251.
- [21] Hayes, J. P.; Knight, L. A. Newnes, L. B.: *Designing In A Group – How Can Knowing Each Other Influence Design Projects?* In: *Proceedings of the International Design Conference DESIGN, Dubrovnik, 2008.*
- [22] Kleinsmann, M.; Dong, A.: *Investigating the Affective Force on Creating Shared Understanding.*

- In: Proceedings of the ASME 2007 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2007 September 4-7, 2007, Las Vegas, Nevada, USA.
- [23] Kleinsmann, M., Valkenburg, R., and Buijs, J. (2007). Why do(n't) actors in collaborative design understand each other? An empirical study towards a better understanding of collaborative design. In: *CoDesign*, 5(1), 1-15.
- [24] Cifre, E., Salanov, M., Lloren, M. and Martínez, I.: „Time Pressure, Subjective Well-Being and Task Performance among Electronic Work Groups“. In: *Occupational Health psychology: Europe 2001*. EA-OHP: 2001, pp. 58 - 61.
- [25] Chong, D.: The Impact of Time Pressure on Teams in New Product Development. Seminar at the the Institute of Electrical and Electronics Engineers (IEEE) United Kingdom and Republic of Ireland (UKRI) Section Event, 27th April 2005.
- [26] Everaert, P, Bruggeman, W.: Cost Targets and Time Pressure during New Product Development. University Gent Working Paper, 2002.
- [27] Svenson, O., and Maule, A.J.: *Time Pressure and stress in Human Judgement and Decision Making*. New York: Plenum, 1993.
- [28] Sullivan, Ed.: *Under Pressure and On Time*. Microsoft press, 2001.
- [29] Pulm, U., Stetter, R.: The function and consequences of pressure in product development processes. In: *Tools and Methods of Competitive Engineering - TMCE 2008 : proceedings of the seventh international symposium*. Izmir, Turcja, 2008 .- Delft : Delft University of Technology, 2008 .- Vol. 1.
- [30] Pulm, U., Stetter, R.: Influences of Pressure on Cooperative Product Development. Invited for publication in *CoDesign*, Special Issue: Comprehending Factors Influencing Cooperative Product Development, appearing in 2009.
- [31] Jones, G. & George, J. M. (1998) The experience and evolution of trust: Implications for cooperation and teamwork. *Academy of Management Review*, 23, 3, pp. 531-548.
- [32] Costa, A.C. (2004). Trust. In: C. Spielberg (Ed.) and J.M. Prieto (section Ed.) *Encyclopedia of Applied Psychology*. Volume 3, Elsevier: Academic Press. ISBN: 0-12-657410-3, p. 611-620.
- [33] Costa, A.C. (2003). Understanding the nature and the antecedents of trust within work teams. In B. Nooteboom and F. Six (Eds.), *The Trust Process in Organizations*. (pp. 105-124) Cheltenham UK: Edward Elgar Publishing.
- [34] Abrams, L., Cross, R., Lesser, E. & Levin, D. (2003) Nurturing interpersonal trust in knowledge-sharing networks. *Academy of Management Executive*, 17, 4, pp. 64-77.
- [35] Ichijo K., Krogh G., Nonaka I., Knowledge enablers, in: G. von Krogh, J. Roos, D. Kleine (Eds.), *Knowing in Firms: Understanding, Managing and Measuring Knowledge*, Sage Publications, London, 2000, pp. 173–203.
- [36] Von Krogh, G., Ichijo, K. & Nonaka, I. (2000) *Enabling knowledge creation: how to unlock the mystery of tacit knowledge and release the power of innovation*, Oxford ; New York, Oxford University Press.
- [37] Slovic, P.: Perceived risk, trust and democracy, *Risk Analysis*, 13, 1993, 675–82.
- [38] Luhmann, N. (2000): *Vertrauen. Ein Mechanismus der Reduktion sozialer Komplexität*. Stuttgart.
- [39] Pulm, U., 2005, Product Development as a Complex Social System. In: *Proceedings of the International Conference on Engineering Design ICED 05, The DesignSociety, Melbourne, August 15–18, 2005*.
- [40] Stetter, R.; Lindemann, U.: Transferring Methods to Industry. In: Clarkson, P. J.; Eckert, C. M. (EDS.): *Design process improvement*. Springer 2005.

Contact: Prof. Dr.-Ing. Ralf Stetter
Hochschule Ravensburg-Weingarten,
Postfach 1261, 88241 Weingarten, Germany
++497515019822
stetter@hs-weingarten.de