

Comparative analysis of the understanding of 'expertise' and 'resilience' in novice and expert anesthesiologists

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**Comparative analysis of the understanding of
'expertise' and 'resilience'
in novice and expert anesthesiologists**

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Abstract

Anesthesiology is the medical specialty dedicated to the relief of pain and care of the surgical patient before, during and after surgery. Most of the work in anesthesiology is routine patient care, but because patients are sick and surgical procedures may develop in unexpected ways, anesthesiology by its nature often involves medical crises.

In recent years, two concepts have gained increasing importance in literature on safe patient care in anesthesiology: the expertise of the caregiver in routine and crisis situations as well as resilience and the ability of the caregiver to ‘behave resiliently’. All studies identified in the literature review, in which anesthesiologists were interviewed on expertise or resilience, used an inhomogeneous set of novices and experts as study group. No study has yet looked at how novice anesthesiologists who for example just graduated from medical school conceptualize expertise and resilience.

In this qualitative, exploratory study, a group of nine novices from the Department of Anesthesiology of the University Hospital Erlangen, Germany, with a mean clinical experience of 4.3 months were interviewed about their understanding of ‘expertise in anesthesiology’ and ‘resilience in anesthesiology’. Their responses were contrasted with the perspectives of nine expert anesthesiologists from the same department, averaging 26.7 mean years of professional activity in anesthesiology.

Novices found it difficult to talk about or define expertise as they still struggled with translating theoretical knowledge into action and with acquiring vital skills. The complexity of routine tasks in new environments was the major challenge for novices, a challenge that experts no longer remembered much about from their residency training. A common understanding shared by novices and experts was that the development of expertise is not an individualistic endeavor but rather a socially embedded process. Novices appeared to think that following written procedures would guarantee safety because they were specific enough to address every clinical contingency. Experts took the view that rules and standards were essentially underspecified, requiring experience and expertise to translate, adapt and enact them. While experts were able to describe how they negotiated standards and recommendations with clinical experience, novices stated that evidence-based or institutional standards seemed to play a subordinate role to the quasi-normative rules of attendings. Novices conceptualized decision making as a very rational, conscious, and deliberate step-by-step process and did not reveal any understanding of tacit knowledge or intuitive decision making. Experts, in contrast, described intuitive decision making and used terms like “intuition”, “gut feeling”, and “7th sense”.

The increasing interest of safety scientists to understand safety by applying the concept of resilience is hampered by the fact that the term is often used in multiple, diverse and, sometimes, incompatible ways. Anesthesiology is no exception to this rule and as it appears that the notion of ‘resilient behavior in anesthesiology’ is actually a relabeling of non-technical skills. In addition, the way ‘resilience’ is used in anesthesiology focuses on individual behavior and often ignores the fact that resilience is a system property that emerges from the interactions at the micro/meso/and macro level. It is questionable

whether this re-labeling of non-technical skills to 'resilient behavior' will improve the practice of anesthesia or create any new insights.

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1 Introduction

Modern surgical care is inconceivable without anesthesiology¹, the medical specialty dedicated to the relief of pain and care of the surgical patient before, during and after surgery. The practice of anesthesiology comprises more than just putting people to sleep: it involves evaluating the patient medically before surgery, consulting with the surgical team, supporting life functions during surgery, providing pain control after surgery, and discharging patients from the recovery room.

Because patients are sick and surgical procedures may develop in unexpected ways, anesthesiology by its nature often involves medical crises. Longer periods of quiet can be suddenly punctuated by brief and highly stressful periods of performance demands: the anesthesiologist's "hours of boredom and moments of terror" (Gaba, 2010). As soon as the patient's physiological state starts to deteriorate, anesthesiologists need a completely different set of abilities. First, they need to have criteria about when to trigger the process of intra-operative escalation (Bergström, Dekker, Nyce, & Amer-Wahlin, 2012) because it is normally anesthesiologists alone who decide whether a particular event is significant enough to be considered a critical incident (Smith, Goodwin, Mort, & Pope, 2006). Second, constant situation assessment, resource management, teamwork abilities, and leadership are needed to successfully manage these medical crises and to stabilize the patient's vital functions. These abilities have traditionally been described in the conceptual framework of 'non-technical skills' (Flin, O'Connor, & Crichton, 2008) and only recently as 'resilient behavior' (Cuvelier & Falzon, 2008, 2011; Prielipp & Birnbach, 2016; Schnittker & Marshall, 2015; Smith & Plunkett, 2018; Staender, 2015). It is an unanimous opinion in fact that effective crisis management is a key requirement for and a hallmark of expert anesthesiologists (Gaba, 2010).

It appears from what has been said so far, that two important concepts form the basis of safe routine and emergency patient care in anesthesiology:

- the expertise of the caregiver in routine and crisis situations and
- the ability to 'behave resiliently'.

2 Theoretical foundations

In the following part the results of the literature review are presented. The review was guided by the following research questions:

- How do anesthesiologists describe the task characteristics of their work environment?
- What are the current conceptualizations of 'expert' and 'expertise' in general and what does the literature tell us in particular about how these concepts are understood in anesthesiology?
- Has there been any research done that compared experts' and novices' understanding of these terms?
- And finally, how is resilience defined and how is the reception of this term reflected in the anesthesiological literature?

¹ Throughout the manuscript, the American spelling (Anesthesiology, Anesthesiologist etc) has been used

2.1 Requirements for routine work

In interviews with Swedish anesthesiologists, Larsson was able to identify four ways in which anesthesiologists related to their routine work: as ‘the professional artist’ who provides anesthesia and controls the patient’s vital functions, as ‘the good Samaritan’ who helps the patient by alleviating pain and anxiety, as ‘the servant’ who gives service to the whole hospital to facilitate perioperative patient care and work flow, and as ‘the co-ordinator’ who helps make operations run smoothly (Larsson & Holmström, 2009; Larsson, Holmstrom, & Rosenqvist, 2003). From the responses given in interviews with Finish anesthesiologists, Klemola and Norros were able to identify two different ways in which anesthesiologists relate to the patient, resulting in two distinct kinds of professional practices (Klemola & Norros, 1997): In the ‘objectivist orientation’ anesthesiologists treat their patient as a natural object without any or much uncertainty. They follow an explicit, fixed preoperative plan and generally display reactive habits of action. This thinking about professional activity as a process characterized by rigorous application of general principles to concrete problems possibly reflects attitudes, skills, and epistemology learned in traditional medical education and thinking (i.e., explicit textbook knowledge). What the authors missed in this approach was the understanding of the need for variability and adaptation in routine as well as in emergency situations, which are main characteristics of ‘non-technical skills’ or of ‘resilient behavior’. The ‘realistic orientation’, by contrast, is characterized by an extensive use of situational information and an aim to construct a cumulative interpretation of a patient’s physiological state. In the ‘realistic orientation’ anesthesiologists recognize a constant need for adjustment as a result of the complexity and uncertainty of real-world problems. Variability and adaptation enable the anesthesiologist to tailor the treatment to varying conditions and patient needs. These attitudes and skills are usually not associated with traditional medical education or prevalent medical thinking, but are a prerequisite for expertise in anesthesiology (Glavin, 2009).

2.2 What is expertise?

Expertise is consensually defined as elite, peak, or exceptionally high levels of performance given a particular task or within a given domain. The nature of expertise has been studied in two ways (Chi, 2006): First, in an ‘absolute approach’ with a focus on truly exceptional individuals (e.g. artists, scientists) on the assumption that these individuals somehow have different global qualities and understanding of their cognition. Because few people fulfil the criteria of an exceptional individual, few can become true experts. Second, in a ‘relative approach’ which assumes that there exists a continuum of capability between novice and expert and that expertise is a level of proficiency that novices can often achieve. Ordinary people have within them the potentiality for expertise, should they be able to acquire the necessary domain knowledge and make the commitment of study and practice. In this perspective, expertise is created and maintained through collaborative and social processes, as well as through the perceptual and cognitive processes of the individual (Ericsson, Charness, Feltovich, & Hoffmann, 2006; p.206). Here, the more knowledgeable group at the one end of the continuum can be considered ‘experts’ and the less knowledgeable group at the other end ‘novices’. A person who achieves the highest level of expertise is called an expert or some related term (e.g. master, virtuoso, prodigy, genius). For different positions on this continuum, some authors have posited several categories (e.g. novice, advanced beginner, competent, proficient, and expert) and have argued for specific criteria for the

various classes (Hoffman, 1998). For the purpose of this study, which is the comparative analysis of physicians at the beginning and at a very advanced stage of a lifelong professional formation, expertise is understood as a relative rather than an absolute difference between individuals.

Another important distinction pertaining to the topic of this thesis is the understanding that expertise occurs in and reflects dynamic domains where situation assessment, action and environmental response are part of a continuous perceptive cycle (e.g. firefighting, emergency medicine; Croskerry, 2005; G. Klein, 1992). This is different from expertise in static domains where tasks might be confined to more fixed tasks (e.g., assessor) or to the flawless execution of motor skills (e.g., musicians, athletes).

The social sciences add the perspective that expertise does not reside solely in the heads of experts (as can be concluded from observing manual skills or the different approaches to problem solving) but that it is also an attribution that resides in social processes and social groups (Carr, 2010). Expertise is inherently ideological not least because it is implicated in semi-stable hierarchies of value that authorize particular ways of seeing and speaking as expert

Finally, expertise in a complex real-world setting (e.g. an operating room) also includes the aspect that the expert must have a sound grasp of the organizational, social, and political contexts of practice that may affect his or her efficiency. This knowledge allows the expert to act in an adaptive way given the constraints and changes of the work environment (Patel, Arocha, & Kaufman, 1998).

Features of expertise

A wealth of research on expertise has resulted in a list of features of expertise that can be found across many domains in art and science (Chi, Glaser, & Farr, 1988; Ericsson et al., 2006; Hoffman, 1998):

- Expertise is *limited in scope* to a very specific activity. Experts excel mainly in their own domain and cannot transfer high-level proficiency in one domain to proficiency in other domains – even when the domains seem, intuitively, very similar.
- Expert *knowledge differs* from novice knowledge *in its organization as well as its extent*. Experts cognitively organize the perceptually available information in their working environment into larger meaningful patterns. At a more principled, functional, and abstract level, they perceive the ‘deep structure’ of a problem or a situation. As a result, experts can detect and see features that novices cannot.
- Because their knowledge is stored as a ‘meaningful whole’, experts can retrieve relevant domain knowledge and strategies quickly with *minimal cognitive effort*.
- Experts spend a relatively *great deal of time analyzing a problem* qualitatively. Thereby they can build a mental representation from which they can infer relations that define the situation, and they add constraints to the problem.
- Because an expert’s problem solving is primarily influenced by very domain-specific acquired patterns and associated actions, they can *quickly solve problems* with little error.
- Experts can execute their skills with *greater predictability* and are able to exert greater cognitive control over those aspects of performance where control is desirable. As a result, experts can be faster than novices at skilled performance in a given domain.

- As a result of a long professional life spent *familiarizing with and adapting to the variability* of their work environment, experts often possess knowledge and adaptive strategies that do not appear in documents and task descriptions.
- Experts have *more accurate self-monitoring skills* in terms of their ability to detect errors and the status of their own competence prehension.

To summarize, expertise involves considerable domain and procedural knowledge, skilled intuition (Kahneman & Klein, 2009) and an extensive but limited repertoire of skills and heuristics. Skilled intuition will only develop in an environment of sufficient regularity, which provides valid cues to the situation which then can be cognitively organized on a more principled and abstract level. A necessary condition for the development of expertise is an adequate opportunity to learn the relevant cues and to practice the skills. In some domains, this ‘adequate opportunity’ for expertise to develop has to be present for over a decade. Herbert Simon studied in detail the mental processes involved in the cognitive processes of chess masters and argued that a chess master can recognize 50.000 different configurations of chess, an expertise which is achieved after about 10.000 to 20.000 hours staring at chess positions (Chase & Simon, 1973). Recent research has suggested a qualification to this ‘ten year rule’ for other professional domains (Hoffman & Lintern, 2006).

2.3 How do we know that someone is an expert?

Although experts have been studied for over a century, there remains a critical question – how can we describe who is, and who is not, an expert? If external criteria (a ‘gold standard’) would exist, then identification would be straightforward. Unfortunately, such criteria are seldom available for domains where experts work; that’s why experts are needed in the first place (Shanteau, Weiss, Thomas, & Pounds, 2000). On the other hand, when taking the ‘absolute approach’, a comparison with standardized criteria might not be necessary, because the extraordinary performance of the expert individual would speak for itself: it would be the unbelievable musician, the outstanding actor, the brilliant scientist, or the extraordinary athlete. In a ‘relative approach’, however, the determination of who an expert is in a given domain and who not may not be that straightforward and can require a type of proficiency-scaling procedure (Table 1; cf. Chi, 2006; Hoffman & Lintern, 2006; Shanteau et al., 2000). In most of the situations studied by researchers in real-world situations (as opposed to laboratory studies with artificial tasks) the criteria for judging expertise are based on a history of successful outcomes rather than on any quantitative performance measures. The most common method for defining expertise in Natural Decision Making (NDM), which would include research on expertise in anesthesiology, is to rely on peer judgments (Kahneman & Klein, 2009). The use of peer judgments can distinguish highly competent decision makers from mediocre ones who may spent a comparable amount of time in the same domain but who have not yet become expert performers: “(...) experts are operationally defined as those who have been recognized within their profession as having the necessary skills and abilities to perform at the highest level (Shanteau, 1992b; p. 255).

Table 1: Different approaches to identify experts (adapted from Chi, 2006; Hoffman & Lintern, 2006; Shanteau et al., 2000)

Approach to identify experts	Associated problems with the approach
Years of job-relevant experience	<ul style="list-style-type: none"> • Experience is an uncertain predictor of performance. Simply doing the same thing for long periods does not increase quality of performance; it merely makes tasks less effortful and automatic. At worst experience reflects seniority – little more.
Certification or academic credentials	<ul style="list-style-type: none"> • Certification is more often tied to years on the job than to professional performance. Performance-based assessments as criteria for professional certification has only recently found its way into the German medical training system. • Academic credentials can be unrelated to job performance. • Accreditation is for life even if skill level of individual declines.
In-depth career interviews about education, training, etc.	<ul style="list-style-type: none"> • Method gives interviewer an idea about breadth and depth of experience, estimates of hours of experience, and credentials. Limitations are identical to the above stated.
Tests of domain-specific knowledge or performance at familiar tasks	<ul style="list-style-type: none"> • It takes more than knowledge or facts for expertise. It is also necessary to see which facts to apply or which task to perform in a given situation, which in most domains is the hard part. • In dynamical domains tests have low validity as they are unable to reproduce the context and task characteristics that constitute naturalistic decision making.
Performance-based indices (e.g. CWS ratio; (Shanteau et al., 2000)	<ul style="list-style-type: none"> • Performance-based indices yield estimates of intra- and inter-expert reliability and consistency of judgment. These indices represent a qualitative approach without normalization for a domain. • Because performance-based indices presuppose a series of repeated stimulus cases to assess consistency and discrimination they are not applicable to the real life context of naturalistic decision making
Social acclamation (Peer assessment)	<ul style="list-style-type: none"> • A more popular, likeable person is more likely to be identified as expert by his or her peers. • Antipathy may prevent peers from naming an individual an expert despite his or her task performance.
Combination of approaches	<ul style="list-style-type: none"> • Slightly more effort needed

Implicit (tacit) and explicit knowledge

Much of the power of human expertise in complex sociotechnical systems lies in knowledge and reasoning strategies that are not easily captured as factual knowledge in textbooks, lectures, existing procedures, or documents. These two different representations of knowledge are termed ‘explicit knowledge’ and ‘implicit (tacit) knowledge’. *Explicit knowledge* is conscious and can be codified: A person is fully aware of what he or she knows here and is able to communicate this information to others. Examples of explicit knowledge are textbook knowledge or best practice recommendations. *Tacit knowledge*, in contrast, refers to aspects of knowledge which are difficult to express by using propositional statements (i.e. statements that can be defined as true or false; Polanyi, 1966). Tacit knowledge is often internalized knowledge and involves physical as well as perceptual skills that are difficult to teach explicitly and are predominantly acquired via direct experience (Patel et al., 1998). With tacit knowledge, individuals are often unaware of what they know and how they obtain particular results. The tacit dimension of knowledge is often perceived by the decision maker as gut feeling or intuition.

According to Polanyi, tacit knowledge represents a higher level of knowledge, integrated and ready to be used. The step from explicit to implicit knowledge is necessary for the development of clinical proficiency. Knowledge changes from being open and explicit to a state where it can stay in the background but, as an integrated part of the professional work, can nevertheless guide the management of a clinical phenomenon or situation (Eisenach, 2009b).

Eliciting expert knowledge

If tacit knowledge is the bedrock of expertise but at the same time difficult to access, then the question arises how to elicit this kind of knowledge. Basically, two possible pitfalls exist when trying to elicit expert (tacit) knowledge: First, the possibility that this tacit knowledge fundamentally lies beyond the expert’s ability to

verbalize or beyond the reach of any research method and second, that if the expert actually manages to talk about how and why she does things the way she does this information might be inaccurate and merely reconstructive (Speelman, 1998). Historically, the possibility of eliciting expert knowledge was often denied by referring to research from Richard Nisbett and Timothy Wilson in the late seventies who claimed that subjects had only limited access to cognitive processes and therefore their verbal reports were not necessarily valid (Nisbett & Wilson, 1977). The authors concluded that some information will always remain beyond the reach of scientific method because researchers cannot expect decision makers to accurately explain why they made decisions. This position was immediately challenged by several authors who criticized the research of Nisbett and Wilson as being selective, incomplete, and suffering from severe methodological flaws (Adair & Spinner, 1979; Ericsson & Simon, 1980; Smith & Miller, 1978). Most probably the claim that some knowledge is fundamentally inaccessible has been a hangover from the heyday of Behaviorism as it has never been demonstrated that there exists such a thing as ‘knowledge that cannot be verbalized in principle’. Although some phenomena append the designation ‘tacit knowledge’, there is no indication that such knowledge lies beyond the reach of science (Ericsson et al., 2006; p.216). “It appears to be more appropriate to differentiate between different representations of expert knowledge: some expert knowledge is represented as spatial or pictorial mental models that are difficult to describe in verbal form, whereas some other expert knowledge is represented in representations that are more amenable to verbalization, such as propositional representations of causal relationships. What determines the way in which expert knowledge is represented appears to be related to the purpose for which the knowledge is used.” (Speelman, 1998; p.146). In addition, experts will be more able to verbalize their knowledge if verbalization is, or is close to, a major feature of expert performance. As a result, experts in domains who routinely attempt to describe their knowledge to others (e.g. physicians in an academic setting with regular clinical teaching obligations) should possess the ability to verbalize their expertise because it is part of the social process by which their expertise was acquired and transmitted.

Table 2: Different knowledge elicitation techniques used to study expertise (Shadboldt, 2005; Speelman, 1998)

Knowledge elicitation technique	Strength of technique	Associated problems with technique
Different classes of interview techniques (e.g. questionnaire, structured, semi-structured, unstructured interview)	<ul style="list-style-type: none"> Expert shares knowledge <i>after</i> the performance which provides a concrete scenario to talk about. Opportunity to engage with interviewee. 	<ul style="list-style-type: none"> Expert performance is guided and triggered by context specific cues. Because contextual details might not be remembered in a neutral environment (e.g. office where interview takes place), the context in which information is recalled should best be the context in which it originally was occurs In an interview, experts may not have access to the same information. In addition, they will only produce what they can verbalize. Non-verbalizable aspects of the domain will not be recovered, and experts tend to give ‘black box replies’: ‘I don’t know why I do that ...’. Justification for decisions may be mere rationalizations.
Talk-aloud study	<ul style="list-style-type: none"> ‘Online’ record of the processes and expert report on the nature of their thought processes occurring <i>during</i> performance. 	<ul style="list-style-type: none"> Experience at thinking aloud is necessary to provide effective protocols. Verbalization only as fast as reasoning, so experts may leave out steps in their reasoning process.

		<ul style="list-style-type: none"> • Having to provide a commentary during performance changes the task situation and may affect the way the task is performed. • The expert may not be able to talk aloud about his task performance if the task itself involves some form of verbal communication and he constantly would have to switch between both communication and tasks.
Field observation and subsequent Protocol Analysis (PA) of video-, audio-recordings)	<ul style="list-style-type: none"> • Expert can be observed performing the task. Expert comment on the performance. 	<ul style="list-style-type: none"> • PA sessions are time consuming. • It is difficult to derive general domain principles from a limited number of protocols.
Critical Decision Method (CDM; (G. A. Klein, Calderwood, & MacGregor, 1989)	<ul style="list-style-type: none"> • Stresses problem solving in natural decisionmaking contexts. Organized around an account of a specific incident from the expert's own experience 	<ul style="list-style-type: none"> • Critical situations are often situations, in which decision making is not confined to one individual but instead distributed to different professions (e.g. firefighter, police, paramedics) • Ability to remember timeline in high workload environments may be impaired.
Concept sorting	<ul style="list-style-type: none"> • Relationship between a fixed set of concepts can be uncovered 	

Over the years, several techniques have been applied to elicit tacit knowledge and to study expertise (Shadboldt, 2005; Spelman, 1998; Table 2). One of the major methodological problem associated with experts providing verbal descriptions of their expertise appears to be the fact that experts are being asked to verbalize about their skills after the performance and away from the environment in which these skills are normally applied. Their expertise may be context-sensitive, and so will not be accessed in the interview situation. As a result, experts will have to rely on reconstructive, after the fact reasoning to provide explanations for their behavior. Asking an expert to exhibit his or her expertise in a manner outside to his or her normal mode of expression can make the expert appear less than expert and the results fragmented, incomplete, and hence of limited value for analysis (Spelman, 1998).

Eliciting knowledge on expertise

The majority of research on expertise has been done so far by studying the decision making and actions of experts or by comparing their performance with that of novices. Rarely have experts been asked to reflect upon the components and the developmental process of their expertise and what they think made them the experts . When there have been an attempt to elicit knowledge on components of expert performance, respondents often had difficulties in verbalizing this knowledge (e.g., in anesthesiology: Cuvelier & Falzon, 2008). Eliciting expert knowledge on how to handle a *concrete* situation (actual or remembered) is not the same as asking experts to reflect upon the *abstract* construct of expertise. However, the same limitations to knowledge elicitation may apply for the expert's understanding of the term 'expertise', even if he or she might come up more easily with explanations or definitions. As a result, it will be important to keep in mind that an expert's statement about 'expertise' (and for the same reason also about 'resilience') cannot be equated with a contextual understanding. Ethnography is done on the premise that it is not the interviewee's task but the quantitative researcher's to reveal and make visible aspects of expertise and resilient work practice that practitioners cannot make explicit. The typical way proposed to address this issue is to move up from context-specific details to concept-dependent generalizations in successive steps.

How does expertise in anesthesiology develop?

Several studies have looked at the learning process of junior anesthesiologists. Although the aim of the studies differed and was either ‘expertise’ (Smith, Goodwin, Mort, & Pope, 2003; Thornton, 2010), ‘excellence’ (Eisenach, 2009a; Glavin, 2009; Larsson, 2004; Smith, Glavin, & Greaves, 2011; Smith & Plunkett, 2018) or ‘professionalism’ in anesthesiology (de Roubaix, 2017; Dorotta, Staszak, Takla, & Tetzlaff, 2006; Kearney, 2005) the results show some conceptual overlap. Several major themes emerged as well:

- *Textbook knowledge is a necessary but not sufficient condition* for expertise. To learn a profession and undergoing the transition from a novice to an expert is a process different from acquiring academic knowledge. Because the level of tacit knowledge acquired distinguishes ‘experts’ from ‘novices’ as well, a core process in this transition appears to be the integration and reconciliation of different types and streams of knowledge (Eisenach, 2009a), the transformation of explicit knowledge to tacit knowledge. Acquiring explicit knowledge may be a necessary first step to ground understanding and action in a valid theoretical framework. However, the way theoretical, explicit knowledge is presented in textbooks (structured, in logical order, sometimes as algorithms) may not help novices in giving that knowledge a tacit dimension (Eisenach, 2009b; Larsson & Holmstrom, 2012) and may have to be partially unlearned.
- *Standards are a necessary but not sufficient condition* for expertise. Inherent in the development of expertise is the ability to discern when clinical guidelines have to be followed and when the patient-specific recognition forbids the application of the same exact guideline and adjustments have to be made. The idea of protocols and guidelines as the only base for learning anesthesiology may actually constitute an obstacle to reaching more advanced levels of expertise by jeopardizing the development of tacit knowledge (Eisenach, 2009b). The reason for this is that expertise always comprises an element of judgement which resists codification as in evidence-based medicine (Thornton, 2010) and, further, evidence-based approaches to professional practice may obscure the role played by the interpretation of knowledge (Pope, Smith, Goodwin, & Mort, 2003).
- *The importance of clinical apprenticeship.* The development of tacit knowledge seems to require direct personal contact between an expert and a learner for transmission to take place. As a result, much of the learning in anesthesiology appears to be apprenticeship-based (Pope et al., 2003). Ideally, novices should learn from their teachers how to blend experience with evidence-based medicine. In reality, however, novice physicians often have to adopt to the peculiarities of their clinical teachers and have to follow the ‘quasi-normative rules’ of their attendings as part of their clinical apprenticeship (Bosk 2003).
- *Doing things on your own.* Experience and expertise are acquired by working independently from other anesthesiologists which allows the novice to develop personal routines and professional autonomy (Smith et al., 2003).

2.4 What is resilience?

In the past two decades, safety science has witnessed a shift in focus from human inability, jeopardizing allegedly safe systems, to human adaptability and flexibility that enables a socio-technical system to successfully cope with the dynamic complexity of the real world. In this context, resilience has become an increasingly popular topic on the safety research agenda. The increasing interest in resilience is not restricted to a particular scientific domain but can be seen in such diverse fields as psychology, biology, ecology, healthcare, and others. Despite the shared use of this term across different scientific traditions neither a unified concept of resilience nor a common theory in which it is embedded (Martin-Breen & Anderies, 2011) has appeared. As a result, the label ‘resilience’ can only function as a general pointer to several concepts (Bergström, van Winsen, & Henriqson, 2015; Hale & Heijer; Hollnagel, Woods, & Leveson, 2007; Woods, 2015). Historically, resilience has been understood as ...

- ... the ability of a psychosocial subject to *cope with adversity*
- ... the ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations even after a major mishap or in the presence of continuous stress”
- ... the ability to *absorb perturbations* which lie within the scope of the model instantiated in the basic capabilities of that system (i.e. regular variability)
- ... the ability to recognize and adapt to *handle unanticipated perturbations* that call into question the model instantiated, and demand a shift of processes, strategies and coordination (i.e. irregular variability)
- ... the ability to *stretch the basic capabilities of a system* so that it can adapt to and successfully handle surprises.
- ... the adaptive capacity of a layered network or complex system that enables to *successfully handle the changes and challenges across its life cycle*.

Although a clear distinction between the different understandings may be helpful in the academic discourse (Woods, 2015) it might not necessarily be helpful in practice where several of these features may be found simultaneously in an organization and may have identical roots and functions. For the purpose of this study and as a starting point for the interview questions about resilience, Hollnagel’s above quoted definition was used which states that

“(...) a system is said to be resilient if it can adjust its functioning prior to, during, or following changes and disturbances, and thereby sustain required operations under both expected and unexpected conditions (i.e. regular and irregular variability)” (Hollnagel, 2014; p183). This qualification of the definition used is necessary to understand the scope of the interview questions, as Hollnagel’s definition(s) of resilience has undergone considerable and substantial changes over the decades (Hollnagel, 2018). According to Hollnagel, the intrinsic ability of a system to adapt and to sustain required operations under both expected and unexpected conditions rests upon four cornerstones (Hollnagel, 2011):

- *Anticipation*: Knowing what to expect, or being able to anticipate developments, threats, and opportunities further into the future, such as potential disruptions or changing operating conditions. This is the capability to address that potential.

- *Monitoring*: Knowing what to look for, or being able to monitor that which changes, or may change, so much in the near term that it will require a response. The monitoring must cover the system's own performance as well as changes in the environment. This is the capability to address the critical.
- *Responding*: Knowing what to do, or being able to respond to regular and irregular variability, disturbances, and opportunities either by adjusting the way things are done or by activating ready-made responses. This is the capability to address the actual.
- *Learning*: Knowing what has happened, or being able to learn from experience, in particular to learn the right lessons from the right experience. This is the capability to address the factual.

With respect to anesthetic patient care, there appear to be (at least) two practical problems with the description of features that enable a system to cope with expected and unexpected variability. First, what is true at the macro- or meso-level of a system may not necessarily be true at the micro-level: even if 'the system' (whatever that abstract term should signify) was designed to anticipate and cope with certain incidents (e.g., intraoperative emergencies) these incidents may still come as an unanticipated surprise to the team caring for a patient. Second, if an expert has experienced a certain critical situation often enough, the event might be classified as 'disturbance' or 'threat' from a systemic perspective (-requiring 'resilient behavior' to address the actual-), but from the expert's perspective as routine crisis management for which he has been trained for. The problematic ties between the micro and meso and macro level may explain the fact that, although resilience is typically conceptualized at the functional level of the system (i.e. resilience as system property), the majority of the empirical studies of resilience actually locates the subject of resilience (i.e. who or what is supposed to be resilient) at the micro-level of the individual actor or the team rather than the macro-level of the system (Bergström et al., 2015). In addition, these studies often do not address the relationship between the macro and the micro. As a result, experience and the experienced practitioner gain critical importance: their flexibility to adapt to various types of pressure, goals, and resource scarcity, as well as their ability in difficult conditions to stay within the safe envelope and avoid accidents are essential for the adaptive capacity of a system. This is certainly true for healthcare in general and anesthesiology in particular, where a direct interaction between humans with little protective socio-technical buffer prevails.

Resilience in anesthesiology

The problem that neither a unified concept of resilience nor a common theory in which it is embedded exist is further complicated by the fact that several studies from anesthesiology started to use 'resilience' as a term encompassing attitudes, skills and knowledge that had previously been part of the portfolio of non-technical and technical skills for crisis management in acute care settings (Flin et al., 2008; St. Pierre, Hofinger, & Simon, 2016). These authors identified 'resilient behavior' in emergency and routine patient care, during non-routine and critical incidents and concluded, that resilience appears to be a crucial characteristic of the expert anesthesiologist. As a result, resilience has received increasing attention as a prerequisite for further improvements in anesthetic patient care (Cuvelier & Falzon, 2008; Prielipp & Birnbach, 2016; Schnittker & Marshall, 2015; Staender, 2015). The question, whether or not this re-labeling is a wise thing to do shall be postponed to the discussion part of this thesis. For the research question it suffices to say that while safety

scientists can easily develop a list with features of resilience for both routine and emergency situations, it might not be an easy task for the clinician to verbalize or even remember ‘resilient behavior’. And although resilience is said to be an essential quality needed in different kinds of situations where disturbances arise, it is recognized as well that ‘these determining characteristics are often easier to note in the case of events of an unusual scale or severity’ (Hollnagel & Sundström, 2006). These difficulties are illustrated by a study where French pediatric anesthesiologists were asked to recall critical situations in which the patient’s life was at stake and where they had managed to cope and get the patient back to a stable condition. For all of them it had been difficult to determine what exactly had enabled them to cope (Cuvelier & Falzon, 2008). Among the reasons stated were ‘instinct’, ‘reflex’, and ‘improvisation’, all concepts too vague to allow a specification of ‘factors of resilience’ and very distinct from the list most researchers can come up with. During the semi-structured interviews of this thesis, participants were asked to give an account of a critical situation that was well managed and to try to list some of the aspects that contributed to the positive outcome (→ Table 4 and 5). In so doing it was hoped that the interviewees may verbalize features of resilient behavior by using their own language to describe the abilities to respond to the actual, to monitor the critical, to anticipate the potential, and to learn from experience.

2.5 A novice’s perspective: an untapped source of information

Novices do not enter the process of professional formation without preconceptions, as a ‘white sheet’ ready to be filled in. Rather, they most certainly will have attended a clinical course in anesthesiology during medical school which among other factors may have influenced their choice to enter a residency program in anesthesiology. They will have some expectations and conceptions about an anesthesiologist’s task characteristics, what it takes to become an anesthesiologist, and about the nature and qualities of expertise in this medical domain. Most certainly these ideas will be sketchy and fragmentary at best when compared to what experts themselves might define in retrospect as having been central to the development of their expertise.

However, when it comes to resilience, it might be difficult as well to elicit knowledge about this concept in novices, because talking about resilience actually presupposes practical experience in the domain which novices will only have in a very limited way. But for experts, too, this request to define resilience can be a challenge. As the above cited study from Cuvelier and Falzon found (Cuvelier & Falzon, 2008), experienced anesthesiologists may display successful behavior that some researchers would term ‘resilient behavior’ on a daily basis without referring to it in resilience terms the way a safety scientist would do.

All studies currently identified in which anesthesiologists were interviewed on expertise used an inhomogeneous set of both novices and experts as study group. Cuvelier and Falzon mention that they interviewed “6 trained anesthesiologists, 4 with many years of experience” (Cuvelier & Falzon, 2008). Klemola and Norros interviewed anesthesiologists with an average experience of 9 years as specialist (Klemola & Norros, 1997). In Larsson’s study population the interviewed persons had from 5 to 27 years of experience as qualified anesthesiologists (Larsson et al., 2003). Another research group published on the interviews with a cross-section of 21 medical, nursing and support staff members from the anesthetic team. Of these 21 people, seven were consultant anesthesiologist with between 2 and 15 years of experience, but the methods part contains no reference to

whether or not novice anesthesiologists were interviewed as well (Pope et al., 2003; Smith et al., 2003). Finally, a single study was identified that addressed the perceptions of recently graduated Certified Registered Nurse Anesthetists (CRNA) on their role transition from student to certified nurse (Tracy, 2017). However, with three years of clinical experience as student registered nurse anesthetist prior to certification, a CRNA does not fulfill the criteria of a novice who has just entered the professional domain. As a result, no study has yet looked at expertise from the perspective of novices who graduated only recently from medical school and who just started to gain clinical experience in anesthetic patient care.

3 Research Question

In addition to the inability to find studies reporting from the perspective of a novice in anesthesiology, we also were unable to identify publications in which expert anesthesiologists had been asked to reflect upon the components and the developmental process of their expertise and what they think made them the experts they are. Furthermore, no study was retrieved that explicitly addressed a novice's understanding of 'resilience' in anesthesiology as compared to an expert's conceptualization and whether their understanding of what resilience is changed over times. Although it is not surprising to find differences between the two groups, this study aims at characterizing the ways in which novices and experts understand 'expertise' and 'resilience' in anesthesiology. By interviewing novice and expert anesthesiologists of a single department at a German university hospital, the interviews are intended to answer the following research questions:

1. Novices start their residency program and intend to become experts. As a result, they might deal with the same problems as researchers do when it comes to understanding 'expertise'. What do novices think 'expertise' entails? What do they think they will need to become an expert? What do they think they have to learn, see, and do in order to get there?
2. What do experts think made them the expert person they are according to the peer judgment? How did that happen? Which language do they use?
3. How do novices and experts value standard operating procedures ("standards") and guidelines and how do they negotiate following written guidance with following one's experience and expertise?
4. Do novices anticipate that they will become resilient and if yes, which terminology do they use?
5. How do experts anticipate, detect, and bridge gaps within the context of actual practice?
6. Do experts describe part of their expertise with vocabulary comparable to the one used in resilience engineering? If yes, which language do they use?
7. What do novice and expert anesthesiologists "do" with our languages of safety? In what respect does their description of resilience differ from the conceptualization and vocabulary safety scientists are familiar with?

4 Methods

Prior to conducting the study, approval by the local ethics committee of the Friedrich-Alexander-Universität Erlangen-Nürnberg was obtained (reference number: 189_18).

4.1 Study design

A qualitative research approach was used here to compare novices' and experts' understanding of 'expertise in anesthesiology' and of 'resilience in anesthesiology'. The approach to qualitative research differs from that of quantitative research in that its primary goal is directed towards exploring human experience and understanding phenomena rather than towards determining cause and effect or predicting and testing certain hypotheses. The qualitative research approach is particularly relevant for understanding the perspectives of the participants as collected in individual interviews. The textual data of the interviews is analyzed with qualitative content analysis methodology (Flick, 2014). The objective in qualitative content analysis is to systematically transform a large amount of text into a highly organized and concise summary of key results. Analysis of the raw data from verbatim transcribed interviews to form categories or themes is a process of further abstraction of data at each step of the analysis; moving from the manifest and literal content to latent meanings (Erlingsson & Brysiewicz, 2017).

4.2 Participant selection

As statistical representativeness is not automatically sought in qualitative research, the sampling strategy should be determined by the purpose of the research project. Similarly, sample sizes are not determined by hard and fast rules, but by other factors (e.g., the depth and duration required for each interview; data saturation (Britten, 2006). For the purpose of this study, the sample of interest contained novice as well as expert anesthesiologists. Residents were included in the *novice-group* if the following criteria were met: a) no prior work experience in anesthesia besides clinical rotations during medical school, b) between 3 to 6 months of clinical experience at our department at the time of the interview. The time frame was chosen to ensure that interviewees no longer were medical students and had gained a limited amount of clinical experience but at the same time were still at the very beginning of their professional formation. Based on numbers of newly employed residents in previous years it was estimated that 7 to 10 new residents would fulfill these criteria during the data collection period between April and October 2019. The investigator approached every novice face-to-face, explained the background and intention of the interview study and asked whether they were interested in participating.

Experts were selected by combining a) the certification level of the staff anesthesiologist ("Facharztqualifikation") as minimum requirement with b) peer vote from the remaining non-certified anesthesiologists and anesthetic nurses at our department. All non-certified physicians as well as all anesthetic nurses at our department were approached by the researcher who briefly introduced them to the aims of the study. They received a list with the names of all certified staff anesthesiologists and attending anesthesiologists (excluding the author) and were asked to name a maximum of ten anesthesiologists who they believe had the necessary skills and abilities to perform at the highest level. Respondents were asked to focus on the perceived expertise of the physician, rather than on sympathy with that person. The frequency distribution of votes determined the list of experts. The

sample size of experts was determined a priori to equal the number of novices. Following the evaluation of the peer assessment the investigator explained the background and intention of the interview study to the nine experts chosen and asked them for their participation.

4.3 Setting

The setting of the data collection was identical for all interviews. Interviews were held at the end of a working day in a breakroom at the authors department. The author provided coffee, beverages, cookies and sweets. No other person was present during the interview besides the participant and the researcher.

4.4 Data collection and analysis

After answering participants' questions about the study and obtaining their written informed consent, the investigator engaged in a 25 to 55-min semi-structured interview with each participant. Semi-structured interviews included specific questions, but they were flexibly conducted so that participants were free to elaborate or discuss associated topics. Basic themes concerning "expertise" were identified from the literature review prior to the interviews (Tables 3 and 4). Additional themes were derived from the interview data. In addition, probing questions about resilience in healthcare published previously (Hegde et al., 2016; Hollnagel, 2011) were included into the list of questions for the semi-structured interviews.

The questions for the novices (Table 3) and for the experts (Table 4) had extensive conceptual overlap and at the same time allowed for the difference in clinical experience. No pilot testing of the interview questions was done. All interviews were audio-recorded using a recording app on the iPad and stored offline as mp3-files for transcription and further analysis. Audiofiles were transcribed using 'f5transcript' (dr.dresing & pehl GmbH) and the resulting *.rtf-files were imported together with the *.mp3-files into 'f4analyse' (dr.dresing & pehl GmbH; www.audiotranskription.de) to create codes, write memos and summaries, and to export quotations. Transcription of audio files was started at the beginning of October, after all interviews had been conducted. As a result of a time lag, transcripts were not returned to participants for comment or correction and participants did not provide feedback on the findings. No repeat interviews were carried out. Field notes were made during the interviews and imported as memos into 'f4analyse'.

Data analysis in qualitative research is a process that always involves an iterative set of analyses and syntheses. This process of thematic analysis groups the data into themes and examines how the themes are interconnected within and across interviews (Pope et al. 2006). Techniques used for analyzing data are annotating, coding, labelling, selection, and summary (Blaxter, Hughes, & Tight, 2006). Coding and labelling need to be inclusive to reflect as many nuances in the data as possible. All of the interviews were analyzed using Kuckartz's approach for qualitative analysis (Kuckartz, 2016). In short, each interview script was read carefully to identify common themes or subthemes within and across all interviews. Coding was deductive when the major themes identified as interview questions in advance were used as coding themes (Tables 3 and 4) and inductive when new themes emerged while reading the interviews. After the first pass through all interviews the text passages of all subthemes were checked for conceptual overlap and subthemes were merged and renamed whenever possible.

In a second pass, all interviews were re-analyzed with the shortened and condensed list of themes and subthemes and the coding was modified if necessary. In a final step, all text passages associated with a certain subtheme were re-checked to be certain their meaning was adequately captured by the subtheme.

Table 3: Semi-structured interview with novices: Leading questions (translated from German)

Question	Background and intention of question
Questions about expertise	
• What was your motivation to become an anesthesiologist?	Open-ended question introducing the interviewee to the topic
• What fascinates you most about this profession?	
• Which tasks are part of being an anesthesiologist?	Scope and task requirements of an anesthesiologist.
• Imagine that we meet ten years from now. What do you think will have changed by then?	Paraphrase of expertise.
• What do you think will need to happen for this change to occur?	Personal account of developing expertise. Can a novice actively contribute to this development or does this 'just happen'?
• What will be your biggest challenges? How will you solve them?	Anticipated problems in becoming an expert?
• Can you remember a recent critical event where you had the impression that there is still so much to learn and that you are still at the very beginning of your professional career?	Perception of novice of how it feels to be a novice. Description of problem solving at novice stage
• Tell me about that situation. How did that feel like?	
• What role does medical textbook knowledge play and what role experience?	Concepts of explicit and tacit knowledge; interaction between these two knowledge representations
• What role do 'standards' play? Is it possible or sometimes necessary to deviate from standards in order to ensure safe patient care? If yes, how do you decide?	Concepts of variability, adaptation and the expert's role in defining when to follow standards and when to deviate.
Questions about resilience	
• Can you remember a recent critical event where you had the feeling that the emergency was well managed?	Eliciting unguided characterization of resilient patient care
• Tell me about that situation. What contributed to the successful management?	
• How did you know when you started to have a problem?	Probing question concerning <i>monitoring</i>
• How did you know how to respond? What went well? Which resources did you need? Which problems/challenges did you encounter? How did you adapt to situational changes?	Probing question concerning <i>responding</i>
• Did you anticipate the development? Do you think that people can actually anticipate forthcoming events? How would you explain that ability?	Probing question concerning <i>anticipating</i>
• In the aftermath of this or any other incident you experienced: how do you <i>learn</i> from that event? What are your personal strategies?	Probing question concerning <i>learning</i>
• As a final question: how would you define "expertise in anesthesiology"? In which respect does this expertise differ from expertise in other specialties?	Assumption that after having been interviewed for 30-45 minutes on practical aspects of expertise, interviewees might be more able to give a theoretical definition.

Table 4: Semi-structured interview with experts: Leading questions (translated from German)

Question	Background and intention of question
Questions about expertise	
<ul style="list-style-type: none"> • What was your motivation to become an anesthesiologist? 	Open-ended question introducing the interviewee to the topic
<ul style="list-style-type: none"> • What fascinates you most about this profession? 	
<ul style="list-style-type: none"> • Which tasks are critical to being an anesthesiologist? 	Scope and task requirements of an anesthesiologist.
<ul style="list-style-type: none"> • Can you remember your first months as anesthesia trainee? How did that feel like to be a novice? What were the challenges? 	Perception of novice how it feels to be a novice. Description of problem solving at novice stage
<ul style="list-style-type: none"> • Meanwhile, you have become an expert anesthesiologist. What has changed in these years? Which factors are responsible for this change? What has made you the person you have become? 	Personal account of developmental process. What was an active contribution/strategy and what did 'just happen'?
<ul style="list-style-type: none"> • If a novice would ask you: "I would love to become such an expert anesthetist as you are; what should I do, read, and learn?" What would you answer that person? 	Personal account of developmental process. Recommendations on strategy to become an expert.
<ul style="list-style-type: none"> • Reflecting upon your personal journey of becoming an expert: What were your biggest challenges? How did you solve them? 	Problems experienced in becoming an expert.
<ul style="list-style-type: none"> • What role does medical textbook knowledge play and what role experience? 	Concepts of explicit and tacit knowledge; interaction between these two knowledge representations
<ul style="list-style-type: none"> • What role do 'standards' play? Is it possible or sometimes necessary to deviate from standards in order to ensure safe patient care? Do you ever stop and think the rules say I shouldn't do it this way, but I think it is better another way? If yes, how do you decide? What do you negotiate during such a decision process? 	
<ul style="list-style-type: none"> • Can you remember a situation where you helped a patient by not following a standard? 	
<ul style="list-style-type: none"> • Questions about resilience 	
<ul style="list-style-type: none"> • Can you remember a recent critical event where you had the feeling that the emergency was well managed? 	Eliciting unguided characterization of resilient patient care
<ul style="list-style-type: none"> • Tell me about that situation. What contributed to the successful management? 	
<ul style="list-style-type: none"> • What would you say was your personal contribution to this successful outcome? Would you say that you developed specific capabilities that made a difference in this situation? 	
<ul style="list-style-type: none"> • How did you know when you started to have a problem? 	Probing question concerning <i>monitoring</i>
<ul style="list-style-type: none"> • How did you know how to respond? What went well? Which resources did you need? Which problems/challenges did you encounter? How did you adapt to situational changes? 	Probing question concerning <i>responding</i>
<ul style="list-style-type: none"> • Did you anticipate the development? Do you think that people can actually anticipate forthcoming events? How would you explain that ability? 	Probing question concerning <i>anticipating</i>
<ul style="list-style-type: none"> • In the aftermath of an incident: how do you learn from that event? What are your personal strategies? 	Probing question concerning <i>learning</i>
<ul style="list-style-type: none"> • As a final question: how would you define "expertise in anesthesiology"? 	Assumption that after having been interviewed for 30-45 minutes on practical aspects of expertise, interviewees might be more able to give a theoretical definition.

4.5 The researcher

All interviews were conducted by the same researcher who at the time of the study was an attending anesthesiologist and had been working at the department for 26 years. The relationship of the researcher to the nine experts was collegial to friendly. Four of the nine novices were unknown to the interviewer prior to establishing first contact. In one case the interviewer had examined the resident (NOV_09) during her final medical exam 5 months prior to the interview. During the data collection period the interviewer kept a diary in which he wrote down his experiences with novices and personal reflections about his relation with novices or expert colleagues as well as how comments and statements from the interviews may have informed his perspective in the subsequent days. This approach to research and writing that seeks to describe and systematically analyze personal experience in order to understand cultural experience is called ‘autoethnography’ (Ellis, Adams, & Bochner, 2011).

5 Results on ‘expertise’

During the interview period, nine novices fulfilled the inclusion criteria and were asked to participate. 79 anesthetic nurses and anesthesiologists returned the questionnaire with the peer assessment of experts. During the brief introduction to the aims of the study many respondents asked the author for further details about what kind of expert he was looking for. The general understanding conveyed by the questions was that there was no such thing as “*the* expert in anesthesiology” but rather that different specialists and attendings could be considered experts in subspecialties, such as an expert in pediatric anesthesia, expert in regional anesthetic techniques, expert in cardiac anesthesia etc. In response to the clarification that they were asked to assess an overall, general expertise, the cumulative rating of the questionnaires returned did not result in a limited number of experts everyone agreed upon but rather a wide range of ratings with only two attendings standing out of the group (#6, #7; Figure 1). The anesthesiologists with the nine highest ratings were asked to participate in the interview study. Interestingly, the three expert anesthesiologists with the least clinical experience (EXP_06, 08, 09) were surprised about the results of the peer voting as they had not considered themselves experts prior to the peer assessment. No potential interviewee refused to participate or dropped out during the interview. Participants gave their written informed consent to the recording and offline-analysis of the recorded data, and anonymous use of quotes for publication. Anonymity and confidentiality of interview data was ensured by replacing the interviewee’s name with either ‘NOV_01 – NOV_09’ (for novices) or ‘EXP_01 – EXP_09’ (for experts).

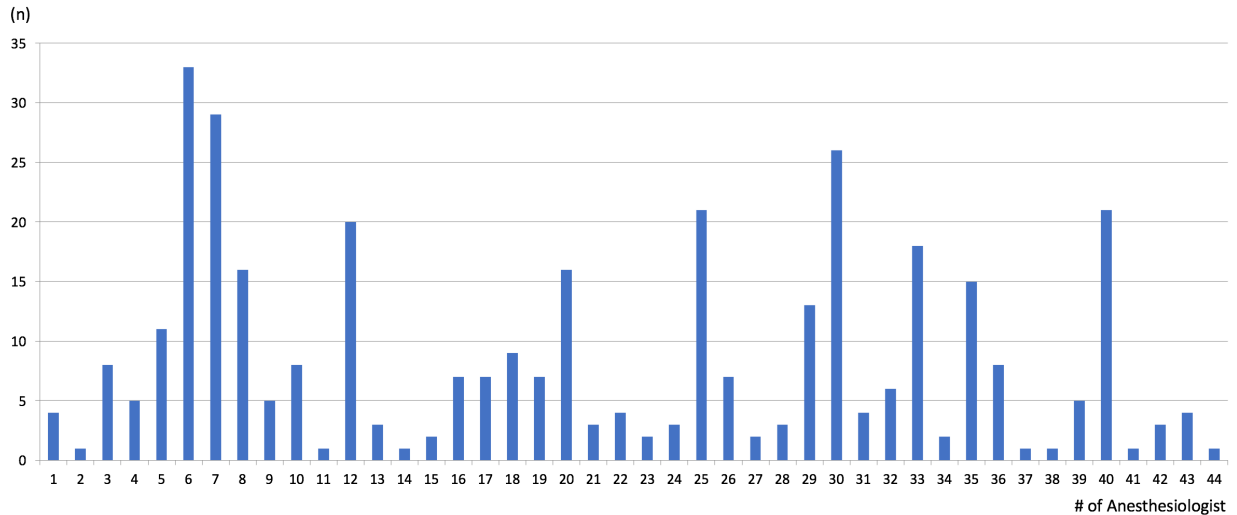


Figure 1: Peer assessment of experts. The ratings from 79 questionnaires resulted in a wide range of 44 anesthetists who were considered by their peers to be expert anesthesiologists. Individuals with the nine highest ratings were included in the expert group.

The mean duration of clinical practice in anesthesia was 4.3 months for novices (range: 3-6 months) and 26.7 years for experts (range: 15-38 years). Two thirds of novices were women, whereas all of the experts were men. This sex ratio reflects the current gender balance at the department. The demographic characteristics of the study participants are summarized in Table 5.

Table 5: Demographic characteristics of participants and duration of interviews

Participant identification	Sex	Months of anesthesia practice	Duration of interview (min:sec)	Participant identification	Sex	Years of anesthesia practice	Duration of interview (min:sec)
NOV_01	F	6 mo	56:12	EXP_01	M	30 yrs	51:03
NOV_02	F	3 mo	25:19	EXP_02	M	29 yrs	43:21
NOV_03	F	4 mo	37:17	EXP_03	M	38 yrs	35:05
NOV_04	F	3 mo	28:00	EXP_04	M	35 yrs	41:08
NOV_05	F	5 mo	28:02	EXP_05	M	37 yrs	36:04
NOV_06	M	5 mo	39:14	EXP_06	M	15 yrs	39:03
NOV_07	M	4 mo	38:18	EXP_07	M	15 yrs	55:00
NOV_08	F	3 mo	32:58	EXP_08	M	23 yrs	42:55
NOV_09	M	6 mo	35:17	EXP_09	M	19 yrs	48:18

Interviews with novices were of shorter duration than interviews with experts (novices: mean duration 35:27 min; range 25:19-56:12 min. vs. experts: mean duration 43:33 min; range 35:05-51:03 min).

The following subheadings reflect the major themes of the content analysis. A detailed discussion follows together along with representative quotations from participants.

5.1 The fascination and scope of being an anesthesiologist

All eighteen interviewees were to some extent enthusiastic about their profession. While the novices' responses often revealed wonder and awe about what they were doing at work (e.g., making people unconscious), the experts tended to qualify their positive attitude by also pointing to negative aspects of their specialty such as the perceived subordinate role to surgeons, aspects of professional politics and having no time for patients. When asked about the scope of being an anesthesiologist, novices almost exclusively focused on their work in the operating room, on learning how to administer anesthetics and how to monitor patients undergoing surgical procedures. Asked, whether there were any other aspects of anesthesiology that she believed to be crucial for the understanding of her specialty, a novice answered

„Well, actually I thought about that a lot before I started to work here. Currently, I'm in that stage where I'm the little beginner and the most important thing I have to learn is how to safely anesthetize a patient and I almost completely blank out everything else ..uhmm.. because, during medical school I found it pretty cool to work in intensive care. But currently all of that is far, far away.“ (NOV_ 2; 13)²

In contrast, when experts talked about what it means to be an anesthesiologist, they described it in more general terms and almost always referred to what in Germany are called 'the four pillars of anesthesiology': anesthesia, intensive care, prehospital emergency care, and pain medicine.

While novices and experts both valued the broad scope of practice and the interdisciplinary nature of their specialty that allowed them to be involved in a wide spectrum of patients (from neonates to multi-morbid elderly) as well as many different areas of medicine, only novices expressed their fascination about the immediacy of feedback and the close correlation between cause and effect when administering anesthetic drugs.

„It fascinated me that you can do something and almost instantaneously achieve an effect. You see, you inject something or you decide something and ..uhmm.. you inject something and can see whether your reasoning was correct or not, whether things change or not. I found that much more rewarding when comparing it with Internal Medicine where you prescribe something and then have to wait weeks to see an effect.“ (NOV_ 3; 3)

Another central aspect of anesthesiology mentioned by novices as well as by experts are the invasive techniques an anesthesiologist has to master in order to anesthetize a patient and to monitor him during surgery. When attempting to outline his reasons for choosing a residency in anesthesiology almost thirty years ago an expert said

„When I look back I don't think that I had much more in mind than these skills, .. uhm .., the handling of invasive techniques, assess the patient's status between awake and unconscious ...uhm .. secure vital functions ... that was my focus ... to learn the relevant skills .. uhm .. and acquire experience, that was my intention. And I think that was the notion of 'this is what an anesthesiologist does' “ (EXP_1;20)

Novices as well as experts valued the fact that anesthesiology appears to be far less competitive than surgical specialties, that hierarchies within their department are more flat, and that people express mutual esteem. Female novices mentioned favorable working conditions and the ability to be able to better combine family and career as another major advantage of entering a residency program in anesthesiology.

² Every quote is specified by the code for the interview (novice/expert) followed by the paragraph from which the quote is taken

5.2 Being novice in anesthesiology

The responses of novices and experts to a similar set of questions regarding the state of being a novice yielded several common themes as well as some revealing differences. It might not come as a surprise that while novices were able to elaborate on the problems of being novice in detail, the experts appeared to have forgotten many of the everyday difficulties characteristic of the first months in a new occupation.

Table 6: Common themes about being a novice and remembering how it was being a novice

Themes	Novice	Experts
• It's about learning the basics and surviving	Very detailed descriptions. Very specific problems: New procedures, environments, people	Very general remarks and being thrown into the deep. A general impression of being overwhelmed and stressed
• Complexity is the challenge	Very specific description about (often mundane) problems and the perceived complexity	No description of situations where they had to cope with complexity.
• The importance of mentoring and supervision	Very general remarks	Very specific: mention names of their tutors and their teaching qualities
• You have to balance knowledge, standards, and quasi-normative rules	The quasi-normative rules are the most important ones for everyday performance	No description of situations where they felt a tension between standards and quasi-normative rules
• The importance of patient safety	Balancing learning and patient safety	You learned from your mistakes
• Progress comes slowly	Very detailed descriptions of the frustrations that progress sometimes appears to be very slow	No concrete memories about how progress was experienced. Instead, received very general remarks about learning one's trade
• Suddenly, you carry responsibility	No longer being a student but being responsible changes your approach	Carrying final responsibility is associated with the feeling of being thrown into the deep
• Aligning knowledge with experience	The gap between knowledge and experience can create constant unease	The gap between knowledge and experience created a feeling of insecurity
• Enjoying work	All enjoy working in a clinical environment, having to take decision and to carry responsibility	They do not remember the positive emotions, only the stress and anxiety

It's about learning the basics and surviving

Novices were able to describe in rich and vivid details how it is to be new in a profession and to have to learn everything from scratch. They report that the knowledge acquired during six intense years of medical school is of no great help when it comes to getting your daily work done. This constant mismatch can make the first months at times frustrating experience.

„You can study medicine and successfully pass your exam and then end up here and it feels like you have never had any experience with healthcare before, because you have to inquire about everything you do. You don't know how to open a cap, how to break open an ampoule, because ... and that is really an awful feeling.“ (NOV_03; 135)

The gap between theory and practice becomes most apparent when novices talk about the difficulties they still have in learning and mastering the manual skills necessary for preparing a patient for anesthesia.

„At the moment, I simply don't have many of these skills. I'm unable to insert a central line all by myself .. uhmm .. with the ease that I have been able to watch in others, so when I saw that I knew: I can't do that yet.“ (NOV_08; 34)

Because some of these skills are necessary to secure a patient's vital functions (e.g., airway management, fluid resuscitation), novices often mentioned the lack of manual skills in the context of questions about remembering a critical event.

„It was this situation together with Jochen, the nurse, where we were anesthetizing this 23 year old patient, who actually was quite healthy, but then I did not manage to intubate her and the sats dropped to low 60s and that was the moment where I thought that things got really dicey but then it was Jochen who said "you were able to mask ventilate her so we've got time" and that was the plan we decided to follow and then things returned to normal.“ (NOV_01; 74)

„Actually, that happens quite often. (...) Today I did not manage to intubate her and Tobi took the laryngoscope and said afterwards that she was a Cormack 2³. Somehow, that is like ... it's often these simple tasks where I think ...“ (NOV_03; 75)

None of the experts reported any of these details when they talked about how it had been during the first months. Often, they talked about their motivation to learn these skills in very general terms.

Complexity is the challenge

One of the major challenges novices face during the first months of their profession is the complexity of tailoring anesthesia to a particular patient with a specific operative procedure. They often describe a feeling of being overwhelmed and the inability to multitask

„That you think on different levels at the same time (...) different tasks, different factors, basically ..ubmm.. you could also say: ensure hemodynamic stability plus perform an invasive procedure plus monitor anesthetic depth and somehow, yes ..ubmm.. it's difficult for me to describe, it's more like all these things you have to attend to at the same time.“ (NOV_02; 76 - 78)

Whereas novices can describe in rich detail the problems they encounter and how quickly they reach their limits, experts talk about the stress of the first months in general terms but not once recount episodes of being challenged by the complexity of everyday work.

The importance of mentoring and supervision

All nine novices described their first months at our department as a time characterized by mentoring and supervision. All of them reported that they felt secure and well supervised, that they always had the option to call for help, that calling for help was actually expected and that help was always available when needed. However, no novice gave a special mention to a particular mentor. This is in contrast to the experts where some individuals still had vivid memories about their mentors:

„At that time, we had a good system, so that you felt comfortable and well looked after. We had these weeks of tutorial and I still remember .. ubmm .. very favorably ..ubm.. Heike Niebuhr, simply because she touchingly took care of me. And of course, you were permanently under stress, you were mindful, and you had, you were nervous in the morning before you started with your first anesthesia .. ubmm .. but because you had this excellent mentoring it actually was a .. ubmm .. pretty .. ubmm .. good and constructive learning.“ (EXP_02; 20)

„Well, I had master teachers. Clinicians. Like the old Grimm, Rügheimer, these were clinicians who said "always look at the patient, he's the most important", this certainly was a very helpful aspect: you always stuck to the patient.“ (EXP_05; 31)

In retrospect, some experts drew connections between their current achievement of having become an expert and the fact that they had been lucky to have had good clinical mentors and teachers during their first years.

³ The Cormack-Lehane system classifies the views an anesthesiologist obtains when he performs direct laryngoscopy based on the structures seen. There are four grades that correlate with the likelihood of difficult intubation. Cormack 1 correlates with an easy airway, Cormack 4 with a very high likelihood of difficult intubation.

„What really counts ..uhmm.. I believe, at the beginning of your career and your profession and when we talk about expertise, is ... It depends crucially on a good teacher, an excellent mentor who will take you by your hand and who has sufficient time for the training and who is empathetic and enjoys teaching.“ (EXP_09; 19)

While the description of being novice was rather positive in the novice group, not all experts had experienced a systematic mentoring and good supervision during their residency training. The most experienced anesthesiologist remembers his first weeks back in the 1980's in a small rural hospital:

„Yes, yes, when I started I wrote down everything I needed on this piece of paper“ [goes to the bookshelf, pulls out an old anesthesia textbook and withdraws a small piece of paper]: “check anesthesia machine, and what to prepare: succinylcholine, endotracheal tubes, and with this paper I had to go on call 14 days later, be on night duty. (...) I think that was a kind of crash-approach.“ (EXP_03; 29)

„At the beginning of your career, they simply threw you into the deep. I only had a short familiarization period (...) and all of us were basically autodidacts.“ (EXP_03; 49)

This feeling of being thrown into the deep appears to be a common experience during the time the current experts started to train in anesthesiology. Two other experts remember:

„I had to finish military service so I had another 6 months after medical school and again, I came in contact with anesthesiology ... in the medical service they asked us "Who of you has worked in anesthesiology?" and because I had had 4 months of clinical rotation in anesthesiology during my final year as student I boldly came forward and they told me "Ok, we need you right away in our military hospital in Munich". So I arrived there, first day, no supervision, no control, they simply said: "Ok, now get started and anesthetize these patients!", that was like being pushed in the water from a 5-meter diving board but of course, these men were all young and healthy.“ (EXP_04; 21)

„That was a problem. This kind of tutorial, of always having someone senior right next to you, did not exist. You went with a more experienced colleague, watched him a couple of days how he did things, and then you were left alone in your OR.“ (EXP_05; 23)

You have to balance knowledge, standards, and quasi-normative rules

Although novices often found it difficult to learn the basics in anesthesiology and to balance textbook knowledge with clinical experience, several of them mentioned that the real challenge for a novice is less to familiarize oneself with the written standard operating procedures (SOP's) at the department, than to learn the unwritten, quasi-normative rules of the supervising attending they are working with

„In daily practice especially as novice you sometimes orientate yourself very much on what the attending might want you to do in a certain situation, even if you have to acknowledge that the guidelines you read tell you otherwise and that the next attending will want you to do things in yet another way.“ (NOV_07; 61)

„Especially when you are a novice you may find yourself thinking: Should I start a norepinephrine-drip or not? How will an experienced person, who may carry the responsibility as attending, react to my decision?“ (NOV_07; 97)

The problem of quasi-normative rules is something that not only troubles novices but which is also identified by some experts as a major problem. In a very self-critical observation, an expert comments

„The attending's responsible for the different operative specialties decide in a very individualistic manner how they ... how they want to have their patients anesthetized. As a result, we have massive, really 180 degrees opposite perspectives and as a novice to cope with this diversity especially if you rotate on a daily basis... On Tuesday, you do the same

things you were praised for on Monday "Yes, that's exactly how I want to have things done around here!" and then you are severely criticized on Tuesday because "This is unacceptable", only to be utterly confused on Wednesday when you're working with the third attending and you no longer know what to do and then you receive a stupid answer when you ask "How do you want me to do it?" and you then get to hear "Well, the same way as always!" (EXP_07; 59)

The importance of patient safety

The mentoring and structured process of familiarizing novice anesthesiologists with their working environment and can be considered to be the result of an increasing awareness of the importance of safety, with anesthesiology as a role model. Already novice anesthesiologists are aware of the critical role of safety. One of the novices commented on the ethical imperative of balancing individual learning with the prevention of patient harm

„But if I'm under supervision of someone more senior than me, then the patient is not at hazard, that is actually the prerequisite, and I can progress a little bit on the ladder. (...) The patient must not be put at risk, I think that is our duty and our task to accomplish that at the best.“ (NOV_7; 27; 29)

This emphasis on patient safety can by no means be taken for granted. Forty years ago, in the 1980's, the professional formation of anesthesiologists and the resources available only allowed for what we would consider today to be below minimum requirements for safe patient care:

„Well I think, as far as I'm concerned when I ..uhmm .. started there that was shortly after the time where Anesthesiology had become an independent specialty (...) where you had physicians for the first time, before, it was the nurses .. uhmm .. risk awareness, I don't know, I don't know, it was ... yes, we kept thinking about it, but it started with the equipment, we didn't have the equipment.“ (EXP_03; 35)

Suddenly, you carry responsibility

Both current and former novices stated that the major challenge for a novice is that he suddenly is entrusted with the control of a patient's vital functions. With the induction of anesthesia, the patient is deprived of any ability to survive on his own and suddenly the novice is responsible for another person's life. An expert remembers the anxiety associated with this new responsibility:

„As novice, you are constantly afraid. You know, the feeling of putting people to sleep is a feeling of controlling incredibly elementary things: The airway, circulation, things which, if they go wrong, will immediately have a major negative impact on the patient.“ (EXP_07; 41)

Aligning knowledge with experience

One of the reasons for this anxiety is the necessity to translate theoretical knowledge into meaningful and appropriate action. Without personal experience that could guide such action, this gap between knowledge and experience effort can become a source of constant unease.

„Of course you can read in a book, but when you're with the patient you always feel somehow blocked, because you don't know: "How am I supposed to apply my knowledge?" (NOV_01; 28)

Based on responses some of the experts gave, it appears as if this anxiety provoking challenge, characteristic of the first months of being novice, can leave a lasting impression. Almost four decades later an expert still can access his feelings from those days:

„Basically, I felt unsecure. I certainly had a lot of theoretical knowledge but I didn't know how to translate that into taking care of a patient.“ (EXP_05; 21)

5.3 What does it take to become an expert?

When comparing novices' and experts' perspectives on what it takes to become an expert, one of the major differences emerging from the interview data was that experts appeared to no longer remember much of the complexity of the work environment and the associated problems of the first months in their new profession. Whereas novices were able to describe situations where they felt challenged, even overwhelmed, by the perceived complexity of routine work:

„Actually, it was not a particularly critical situation, it was a routine anesthesia induction. (...) I felt overwhelmed .. ubmm .. a bit helpless (laughs) .. ubmm .. you try to do your best and to absorb everything they throw at you, but it's simply ...it is too much.“ (NOV_04;71)“

Experts did not detail any situation where complexity had been a problem. In addition, no expert mentioned that one of the primary goals as novice had been to become a calm and effective crisis manager, a goal virtually every novice aspired to become.

Table 7: Common themes about what it takes to become an expert. Novices were asked to reflect upon who they think they will have become ten years from now and what needs to happen. Experts were asked to give a fictive novice resident personal advice on what to do to become the kind of experts they themselves are. (n.m.= not mentioned)

Novice: "10 years from now"	Experts: "What did I do?"
1) Goals and perspectives: I want to be able to ...	1) Goals and perspectives: I wanted to be able to ...
... master my skills	... master my skills
... anticipate what will happen next	n.m.
... cope with complexity	n.m.
... manage crises calmly and effectively	n.m.
... find my own way	... find my own way
... learn how to cope with error	n.m.
... become a good clinical teacher	n.m.
2) What needs to happen?	2) How did that happen?
I did not yet think about that question	n.m.
It's a passive process. It just happens.	n.m.
It's an active process. You have to leave your comfort zone	It was an active process. I constantly left my comfort zone, went the extra mile and took on challenges
I will have to acquire theoretical knowledge	I acquired theoretical knowledge
n.m.	I deliberately took risks and tried new approaches
I will need a supportive environment with clinical teachers and peer discussions	I had a supportive environment with clinical teachers and peer discussions
3) Possible challenges might be ...	3) The challenges I faced were ...
...to know my limits	... to know my limits
... to care for sicker patients	... to care for sicker patients
... the human dimension (suffering, death etc.)	... the human dimension (suffering, death etc.)
... how to stay motivated and to work thoroughly	... to stay motivated
... many new work environments	n.m.
... to balance job and family	n.m.
n.m.	... the interdisciplinary nature of work
n.m.	... the development of leadership skills
n.m.	... to learn to assess risks
n.m.	... to balance safety and economic pressure

Goals and perspectives

‘Goals and perspectives’ entail the aspect that people want to leave a current state behind and arrive somewhere else in the future. Novices were able to give many examples of what they would like to overcome: To no longer be overwhelmed by the complexity of everyday work and to no longer be stressed even by minor unwanted events. Strikingly, these themes are missing in the experts’ recollections: they only remember that they wanted to master their technical skills and find their own way of giving anesthesia to patients.

What can a novice contribute to becoming an expert?

At the time of the interview, the mean duration of clinical practice for the novices was 4.3 months. As a result, many of them talked about how their work days were still filled with a relentless stream of new impressions and experiences. As a result, some novices had not yet thought about this question

„Pooh, currently I’m still so absorbed by learning the basics, yes (laughs) .. uhmm ... I really can’t tell you (...) I have to juggle so many things at the same time.“ (NOV_05; 63)

Others, by contrast, stated that becoming expert will be a passive process which just happens:

„It is an ongoing process; I really believe that it will happen over the years. And that it will come naturally as a result of continuously working in the OR.“ (NOV_02; 39)

„Well, I believe that this will simply happen, actually inevitably happen, it’s like .. uhmm .. and yet, the question remains how high you will climb in the hierarchy.“ (NOV_07; 25)

Asked whether they believed that it would be a passive process throughout the entire residency, some novices qualified their statement by assuming that it was only currently a passive process but that it would become a deliberate choice to actively enlarge expertise, once they had progressed in experience,

„Currently I believe that things just happen, because, you see, at the moment so many things are new to me and every day you experience yet another steep increase in your learning curve because you experience things you haven’t had before. But I think that one day it might become a deliberate choice, one day you may have reached a certain level that might be ok, which certainly is good, but not ... where you still have adequate room for improvement but then you might have to actively face situations that are new and which give you the feeling “Well, I’m not too familiar with this one.“ (NOV_03; 65)

Once it had been pointed out to the novices that their statement about “letting things happen” could be interpreted as mere passivity, novices started enumerating active components such as reading textbooks and attending workshops or conferences. In the majority of cases, the quality of these active components was confined to educational events and only once did a novice mention the aspect of ‘leaving your comfort zone’. Interestingly, even after having been challenged on the aspect of passivity, one novice clung to her opinion that the developmental process of becoming an expert will be a passive one

„Well, actually I’m a person who just takes all these impressions in and takes them as they come. As a result, I think that this change will come over time, it will just happen, and somehow you will have to let it happen.“ (NOV_05; 49)

By contrast, leaving your comfort zone, investing additional time, and deliberately taking on challenges was central to the understanding of experts of what it needs to make progress and to finally excel.

„I believe that if you always want to stay within your comfort zone, you will never acquire this broad range of experience and, in addition, you gain self-confidence and trust in your abilities with every difficult situation you were able to master successfully.“ (EXP_04; 33)

„And I think if you have that kind of approach, that you, let's say don't avoid difficulty, but rather ..uhmm.. say: Yes, this is difficult, I can see that, but I deliberately want to tackle this situation. Well, certainly you don't want to have gamblers in your department, but you always have let's say an experienced attending, at least during daytime where you can say, that he ..uhmm.. he could rush to help in case the situation deteriorates. Yes, you have someone as backup.“ (EXP_04; 31)

„Yes, where others say “I'm not interested” or “It's end of work” or whatever, you should respond instead “Now, that is something special, count me in!“ (EXP_05; 35)

An interesting aspect mentioned by experts was the notion of expertise-development as a self-sustaining process: Once you have developed a certain level of expertise, peers will call you for help in challenging situations which in turn will provide new opportunities to refine your skills and knowledge

„I think it's of course this continuity, this constant learning that you experience because you learn a lot from situations, which in turn contributes to the confidence you will experience one day. That is a never ending process, this development, this education, this additional learning ... meanwhile you are ... uhmm ... they call you for dicey situations and you have to manage them, and that happens because you are constantly confronted with new problems and you learn a lot. And I think, this knowledge accumulates over time.“ (EXP_02; 26)

Challenges on the way to becoming an expert

In commonplace understanding, the term 'expert' may carry the connotation of a person that excels in his or her professional domain and does not need anyone to help or for advice. By contrast, both groups of interviewees believed that every expertise will sooner or later reach its limits and that true experts are well aware of their limitations.

“Of course, experts seek help, yes, yes, certainly. I think that is very, very important. Sometimes you simply don't manage ... and the help doesn't have to be another expert, it can be a first-year resident.” (EXP_08;129)

The challenge appears to be to accept these personal limitations, knowing that this might be in conflict with the common understanding of expertise.

„Ideally, you should of course ..uhmm.. you are capable of critical self-reflection and you tell yourself: I might be better at this here, but the other thing, I better let someone else do it, even if it is another anesthesiologist because you know: she can do that better than me. “ (NOV_07; 21)

„I think that probably the greatest enemy on your way to develop expertise is ..uhmm.. to subject yourself to the dictates that you have to know everything.“ (EXP_01; 58)

Because the attributed status of being an expert can create expectancies on behalf of the expert as well as in his social environment, acknowledging one's limits might be much more of a challenge for an expert than for a novice.

„That's why I believe that (...) it is much easier for a novice to acknowledge: ok, here I certainly need more expertise, I need support and to admit your limits. And also to frankly communicate these limits, is, I believe, much easier for the novice than for the expert.“ (NOV_06; 51)

You need a supportive social environment

Novices and experts both appear to share the understanding that the development of expertise is not merely an individualistic endeavor but rather a socially embedded process that is dependent upon peers willing to share their experiences with others.

“And yet, the question remains how high you will climb in the hierarchy, and I believe one of the key factors is to what extent you are supported by other people, which kind of experiences you gather .. uhmm ... and with whom you work together.” (NOV_07; 25)

„Of course, you can't achieve that all by yourself. Obviously not, you have many colleagues who support you in this development with a constant stream of new ideas, new suggestions, or discussion that you have. How do you do that, for example. As a result, it is not an independent learning process but rather a collective one where you make progress along with your colleagues.” (EXP_02; 28)

For novices, one of the major prerequisites for this kind of learning from peers is a climate where ignorance is not ridiculed and asking questions is actively encouraged

„For me, that is the good thing with anesthesiology: it is a team endeavor, let's say where nobody ..uhmm.. where people don't have a go at you just because you ask, and that's a very precious thing with anesthesiology, that you just can go ahead and ask without having to bother “was that stupid, or what? Should I feel ashamed because I checked back five times?“ (NOV_05; 137)

You have to continue to work thoroughly

Despite the fact that every novice wished for the time when she or he had progressed to a more experienced state, the prospect of finally having become an expert and of having developed some kind of solid professional routine nevertheless carried some negative connotations. Alongside the benefits of expertise, novices also saw a downside in being proficient and well-versed. Asked, why she thinks that routine can have a negative side effect on daily work and what she hopes not to lose once she has become an expert, one novice responds:

„Well, that you feel too self-confident and too well-versed .. uhmm .. that you stop and reflect about the next steps you intend to take .. uhmm .. even if it is not .. if it is an exceptional situation, that you have to stop and start thinking: How come? Why? What do I do next?“ (NOV_04; 35)

Another novice put it even more dramatically when he admitted that for him, imagining himself ten years from now is a frightening idea. Asked to elaborate on this statement the novice continued:

„Maybe they say that back then I was much more carefully and had a diligent approach to problems .. uhmm .. that is a bit like imagining you have the shirt-sleeve approach of the experienced.“ (NOV_06; 31)

5.4 Getting your work done: The relationship between textbook knowledge and experience

The role of textbook knowledge

Having been trained in the academic environment of a medical school, both novices and experts agreed on the importance of textbook knowledge for everyday performance. It informs and guides action on a rational basis. However, there appeared to be a difference with respect to the context of application. While novices read

textbooks or review articles to enhance their basic understanding of how to safely give anesthesia to patients and how certain diseases or operative procedures may interact with the anesthetics, experts no longer felt this necessity because the scientific foundations of their profession had become tacit knowledge. For them, referring to textbooks was only necessary when they encountered unfamiliar problems or rare diseases. In addition, several experts mentioned that they used their physiological and pharmacological knowledge from the textbooks as guiding principle for deciding when to follow a guideline and when to deviate.

Experts, it appears, had learned to act on a blend of theoretical knowledge and clinical experience in which any potential conflicts between them can be resolved. Novices, in contrast, had just begun to struggle with the perceived conflict between what textbooks tell them to do and ‘how things are done around here’. To make things worse for novices, there actually was not one way of ‘doing things around here’ they had to familiarize with, but rather multiple quasi-normative ways, depending on the supervising attending anesthesiologist and given the problem and patient.

„Every, every attending ..uhmm.. decides a little bit differently which means that I can't put a 100% of my textbook knowledge into practice.“ (NOV_04; 91)

During the interviews, novices used the terms “textbook knowledge”, “standards” and “guidelines” interchangeably, basically referring to a bulk of theoretical knowledge that had to be learnt and assimilated. By contrast, when experts used each of these terms the context of speech made it obvious that they knew how to conceptualize and differentiate between them.

Table 8: Common themes about the different roles textbook knowledge and experiential knowledge play in everyday performance. Experts added a third dimension of successful crisis management to the list of themes: a good portion of luck (n.m.= not mentioned)

Themes	Novice	Expert
1) The role of textbook knowledge		
• Informs and guides action	X	X
• Explains experience	X	X
• Helps you to solve unfamiliar problems	n.m.	X
• Explains background for guidelines	n.m.	X
• Becomes tacit knowledge	n.m.	X
• Is different from everyday work	X	n.m.
• Can conflict with quasi-normative approach of attending	X	n.m.
2) The role of experiential knowledge		
• Tells you what works in practice (and not only in theory)	X	X
• Is essential for crisis management	X	n.m.
• Compensates for diminishing factual (explicit) knowledge	n.m.	X
• Contains cases which can't be found in textbooks	X	X
• Provides you with locally relevant knowledge	X	n.m.
3) The third pillar: Luck		
• Sometimes, you just have to be lucky	n.m.	X

The role of experiential knowledge

All of the participants interviewed agreed on the pivotal role experience plays in the development of expertise. Long before levels of expertise are attained, experiential knowledge helps to provide the novice with an understanding about what does, and what does not work in practice. Context-free textbook knowledge has to be implemented into a specific clinical situation and adapted to the pathophysiology of a patient in order to become

relevant. This translational aspect of being able to apply what one has read is crucial for successful patient management:

„Yes, you need both. I mean of course you can provide anesthesia without even understanding what you are doing. Mechanically. But then, I would argue, we could as well place a robot next to the patient who can do the same. And the theoretical knowledge, it's also important, but we had colleagues who were highly intelligent but too stupid to drive a nail into a wall. So, both aspects must ... they are interconnected and ideally –I think today you would call it ‘problem based learning’- but back then we did not have this expression but that's what we did.“ (EXP_05; 45)

For novices, this problem of how to transfer what is written in the book to actual patient care is aggravated when they imagine themselves being suddenly confronted with a critical emergency.

„Of course it is good if you have a lot of theoretical knowledge, but you have to function well in these moments and I think it is experience that tells you what to do next.“ (NOV_01; 82)

Finally, novices stated that they constantly had to orientate themselves in new environments (e.g., when they rotated into a new clinic), so experience provided them with the necessary local information they needed in order to get their work done. This aspect of experience is no longer mentioned by experts.

Both groups were well aware of the fact that the relative importance of theoretical and experiential knowledge tends to change over the years. Asked how he would define the relationship between textbook and experiential knowledge, an expert commented on the shifting relationship between both.

„Well, first textbooks and courses and then experience. So it depends on where you currently are, I believe. In other words, right at the beginning I think it is important that you gain textbook knowledge and attend courses in order to acquire the tools of your trade and once you have improved, then experience has the ... will take over. I would say at the beginning it is definitely 70:30 for the books and courses and then eventually the whole thing tips over and you will end up with, let's say 80:20. 80% experience and the remaining 20% will be that you continue to read, attend courses and so on.“ (EXP_06; 70)

The third pillar: Luck

An unexpected finding from the interview data on the relationship between knowledge and experience was the theme of ‘luck’ that appeared in the expert’s statements. In contrast to a common understanding of an expert as a person with outstanding skills, capable of managing whatever has to be done, expert anesthesiologists often took a more nuanced and self-critical perspective. It appears to be a fundamental experience in acute patient care that a successful outcome is not entirely in the hands of the caregiver. One of the two experts with the highest peer ratings commented on the relationship between ‘luck’ and human action

„There is a rather nice saying from aviation, if I remember correctly, it was called ‘the rules of the aircraft’ and ..uhmm.. there is that phrase basically saying ‘you start with a big bag filled with luck and a tiny bag full of experience and the trick is to fill your bag of experience before you run out of luck. I always found that a helpful comparison, it's appropriate for anesthesiology because that's how things are.“ (EXP_02; 60)

Another expert described a situation where he and his team had to care for a critically ill infant. He commented on the successful management of the pediatric emergency by qualifying

“That was lucky. I don’t say that we did well, I say that was lucky, because we both know that things don’t necessarily have to turn out that way, am I right? (...) You can say that I was lucky, or you can say ‘the good lord watched me work and told me kindly to try hard, it will work out’, but that actually doesn’t make much difference (EXP_05; 69)

5.5 The role of official guidelines and local standards

As mentioned above, novices used the terms “textbook knowledge”, “standards” and “guidelines” interchangeably. At the time of the interview, none of the novices had so far read any official guidelines so that only experts were able to comment on the role they play in everyday performance. Being able to access the original guidelines which often were elaborate publications with a vast amount of references was something only experts found helpful. Novices stated that they needed information in a condensed, ready-to-apply format. This format is provided at the authors’ department by a collection of written local standard operating procedures (= ‘standards’). Novices and experts agreed that these standards provided a valuable introduction to current, safe anesthetic practice.

„Currently, standards play an important for me, they are very helpful if I ... because now at the beginning I always need something to orientate or clear guidance is still the best, precisely because I have no experience, no feeling for it. But I believe, the more experience you gain, the less you need them or you even might not want to follow them that strictly anymore, because experience has taught you otherwise.” (NOV_04;101)

„Standards give you a sense of safety, well, because it clearly states black on white: do it exactly this way and then ..ubmm.. you’re somehow, you can’t be that wrong after all.” (NOV_03; 93)

“The standard is, well, let’s say it that way: the less experience someone has, the more important a standard will be for him or her so that they won’t overlook anything or forget something.” (EXP_05; 53)

“Well, standards do play an important role ..ubmm.. I find them helpful for training because they give structure to someone who is in the process of learning.” (EXP_02; 74)

With the exception of the most senior expert (EXP_03), all experts acknowledged that standards were relevant for their work, too. However, the focus and the mode of application had changed:

„Well I find that it is necessary to create such recommendations and SOPs as an assistance for those who have limited experience in order to give them something to follow. And in case of doubt the experienced can use them as well and check: Did I really do everything that has to be done in such a case?“ (EXP_05; 53)

Negative aspects of guidelines and standards

For all nine novices, guidelines and standards had unquestionable value. They expressed their gratitude that such clear guidance existed and appreciated their practical benefit. In contrast, experts had a more nuanced perspective on the value of guidelines and standards. From the context of the interview in which these statements occurred, it can be concluded that the major reason for their critical stance was the perceived mismatch between a given standard and a particular patient’s circumstances.

„It could be that you don’t meet the standard, but you may more than meet the requirements of the situation.“ (EXP_07; 119)

Table 9: Themes dealing with negative aspects of standards and guidelines (n.m.= not mentioned)

Themes	Novice	Experts
Standards have negative aspects, too, because ...		
• ... they tell you how but not why	n.m.	Experts want to understand the theoretical foundations of guidelines and not just follow them
• ... the underlying evidence may be weak	n.m.	It might be difficult to gauge confidence in the evidence underlying the guidelines
• ... they don't address diversity of people and context	n.m.	Guidelines only address the 'standard patient', not the diverse range of possible clinical conditions.
• ... they can contradict personal experience	n.m.	Sometimes standards conflict with personal experience or with gut-feeling that tells you to act in a specific (at times unorthodox) way
• ... can prevent novices from finding their own way	n.m.	The danger of standards is that novices could use them as a 'cook book' and fail to find their own way of caring for patients
• ... they fulfill mainly financial purposes	n.m.	If patients are not treated according to evidence-based guidelines, payments can be denied for non-compliance

Violating standards and guidelines: necessary, possible, or unacceptable?

During the interviews, this apparent tension between following guidelines and standards and listening to your experience became most apparent when the topic of 'violating standards' was raised. The majority of novices actually found it difficult to answer the question, as they had just started to learn the basics of their future profession with the help of institutional standard operating procedures. One novice replied

"Well, somehow it [the question] is too early for me. Because it is ..ubmm.. as a novice you are glad that standards exist because ... of course you have to act on something, so I think that it is good to agree on standards that have proven their value and which are somehow ..ubmm.. evidence-based, where you know that it makes sense to do what they tell you to do (NOV_01; 98)

From the way the novices framed their responses, it became obvious that they had the standard operating procedures of our department in mind. The concept of a guideline, issued and authorized by a scientific body, did not mean anything to them yet. Some of the novices' responses can be interpreted as if they assumed that standards were specific enough to actually address every clinical contingency and that following written procedures would guarantee patient safety:

„Create safety by violating standards? Hmm, actually that sounds a bit contradictory, because it's the standards that should give you safety. Well, I guess in that case the standards are not elaborated enough, because normally, they should ..ubmm.. yes, specify how to do the work.“ (NOV_02; 125)

„Standards give you a sense of safety, well, because it clearly states black on white: do it exactly this way and then ..ubmm.. you're somehow, you can't be that wrong after all.“ (NOV_03; 93)

In accordance with the limited clinical experience gained so far, the novices' discussion of balancing standards with personal experience was mainly a theoretical one. The novices' interpretation of an utter reliance on standards was not once given by experts. On the contrary, the experts' statements reflected a long professional life filled with daily internal negotiations between experience and written guidance. While the conclusion that standards sometimes have to be violated for the sake of safe patient care was identical among the experts, the underlying arguments showed some variability (Table 10). In essence, however it was agreed upon by all experts that one of the main characteristics of an expert was that he had learned how to negotiate this conflict successfully.

„In this type of situation, the guidelines would recommend (...) and you say: Yes, BUT! And you have to be capable to justify this 'but', that's the crucial point.“ (EXP_05; 55)

Table 10: Common themes about which criteria are being used to decide when to violate standards and recommendations (n.m.= not mentioned)

Themes	Novice	Experts
Criteria to decide		
• Deliberate negotiation between evidence and personal experience	Either no position (too early) or theoretical deliberations	Responses reflect practical experience with negotiating evidence and standard
• Individual risk assessment	Talk about risk when referring to not following standards	Talk about daily tradeoffs and the necessity to actively engage in this assessment
• Pathophysiological knowledge as arbiter	n.m.	Recurrent theme among experts
• Tailor standard to patient need	Theoretical deliberations	Explanations center around standards applying for 80-90% ('mean±2 standard deviations') and the remaining population needing a more individualized approach
• Gut-feeling	n.m.	Talk about switching to the 'gut-feeling-mode'
• Peer discussion	Discussion with experienced colleagues helps to gain clarity about the next steps	Discussion with peers sometimes helps to gain clarity about the next steps
• The 'Golden rule'	n.m.	"Ask yourself: would I like to be treated this way if I was in this situation?"
• The alleged patient will	n.m.	"Ask yourself: would the patient have wanted me to treat him this way?"

5.6 Decision making: the novice's perspective

The responses of novices, while discussing the negotiation of standards and personal experience as guidance for action, provided some insight into how novices conceptualize decision making. In their reflections, they described decision making as a very rational, conscious, and deliberate step-by-step process. Their responses contained no references to tacit knowledge or intuitive ("gut feeling") decision making.

„And I hope that my experience, which I will have gained over time will kind of help me to say: ok, in this case the textbook would tell me to do it this way, but no, I ..ubmm.. dare to do it differently because I think that I now have gained so much expertise that I can dare to do it my way.“ (NOV_05; 111)

Novices described decision making as a rational process on many other occasions throughout the interviews. For instance, similarity matching was not described as a heuristic, but appeared to be an active effort to search one's mental library for similarities:

„I try to think about what kind of patient am I currently anesthetizing, how will she wake up, what set of problems might she have, did I have something similar in the past? And I always do, I try to give thoughts to the question, whether I have seen something similar before.“ (NOV_03; 91)

In a similar vein, having become an expert ten years from now is not described as having acquired 'gut-feeling' but rather as being able to counter a challenging situation with an active, rational chain of thought

„I sometimes imagine that an expert carries a very extensive flowchart in his mind and knows: if this, than that and if this and that, than preferably this option.“ (NOV_08; 93)

„Ten years from now I hope that I will stay calm not least because I have seen a lot and because I somehow have gained experience ... that I simply know that I can stay reasonably calm because I have already seen something similar or at least, yes, know how to manage this situation and as a result are capable of radiating confidence. (...) I think if I can tell myself: yes, ok, I have already managed this or that and have seen something similar, I have reason to believe that I can handle that, and I think that you will only have the reason to believe that if you have gained experience, if you have already seen all kinds of different situations.“ (NOV_03; 51, 53)

„I think [ten years from now] I will be, let's say really confident because I can draw from a treasure of genuine experience or from experience others shared with me. As a result, I can tell myself: In that kind of situation I have

gained good experience or bad experience with a certain response, and that's why I choose to do the same or not to respond in a similar manner.“ (NOV_07; 21)

„I believe that once you have experienced many difficult situations which you were able to manage successfully, then you will have a couple of ideas about how to cope with situations, even if they are completely new to you ..uhmm.. because you can draw parallels to other cases you had in which you might have successfully tried this or that and as a result you have a much larger pool of experience to draw from.“ (NOV_01; 48)

In contrast, experts conceptualized decision making on both levels, rational deliberation and gut-feeling. This shall be explained in what follows about expertise.

5.7 What is expertise and who qualifies as an expert?

Novices and experts had some understandings of expertise in common, but experts mentioned in addition many aspects of expertise that may reflect decades of practical experience (Table 11).

Table 11: Common themes about characteristics and limitations of expertise (n.m.= not mentioned)

Themes	Novice	Experts
Characteristics of expertise are ...		
• ... not identical with board certification	A physician who is not yet a certified specialist can still be an expert	The board certification makes new learning opportunities possible which will increase experience
• ... profound knowledge	Blend of theoretical and practical knowledge	Blend of theoretical and practical knowledge
• ... fluidity of performance	Skills allow for fast, flawless performance	Skills allow for fast, flawless performance
• ... large amount of experience and routine	The hallmark of being an expert	The hallmark of being an expert
• ... crisis management skills	The hallmark of being an expert; personal skills	The hallmark of being an expert; personal skills and a portion of luck
• ... intuitive problem solving ('gut feeling')	n.m.	The aspect of intuitive decision making is only mentioned by experts
• ... ability to assess and to take risk	n.m.	The aspect of risk assessment of patients scheduled for surgery and of deliberately taking risks when anesthetizing a patient
• ... team play and interdisciplinarity	n.m.	The focus of the expert is on the interdisciplinary nature of daily work
Limitations and disadvantages of expertise are ...		
• ... the limited scope	n.m.	Experts differentiate between the general expertise of being anesthesiologist and the limited scope of expertise within a subspecialty
• ... the 'expiry date'	n.m.	Experts know that knowledge can fade and skills can deteriorate
• ... the empowerment to set up 'quasi-normative' rules	Expertise gives you the authority to set up your own quasi-normative rules and expect novices to follow them	Expertise gives you the authority to set up your own quasi-normative rules and expect novices to follow them
• ... the possibility of becoming too self-confident and negligent	Experts appear to have a 'sloppy' and negligent approach to work	Experts are the ones who are not content with easy and quick solutions but who stick to a problem until it is solved
• ... the increasing workload for experts	n.m.	Because experts are called when everyone else has reached his limits they always have to work more than others

Expertise and board certification

An important step in the professional formation of a physician is the board specialist examination (in German: "Facharzt"). While both groups agreed that being a board-certified physician and being an expert are not identical things, they interpreted this independence differently. For novices, a person could be considered an expert even before he or she had undergone this examination.

„I could imagine that someone is an expert in a certain area even before he is a certified physician, that someone can have a lot of experience in a certain area even if this has not yet contributed to his certification as anesthesiologist.“ (NOV_08; 59)

Asked whether he believed that there is a difference between a board-certified specialist and an expert, a novice responded

To be an expert is independent of the level of professional formation ... A board-certified specialist, that is only a title (...) and there are certainly colleagues who are on the verge of registering for the board exam who have at least the experience of a certified specialist and that's why I would not equate expertise with being a certified specialist" (NOV_07; 45)

For experts, expertise would only start to develop after the certification, because the certification created a new space of responsibility and new challenges, which in turn would affect the amount and quality of the practitioner's experiences.

„And you learn a lot and shortly before your board certification as specialist you have very strong theoretical foundations, but all the practical experiences, they come after your certification. Because it is then that you do all those things you have never done before because now you are the only one around who can do them. And that is this learning after having become a specialist where you start to lose much of your theoretical knowledge but where you then ..uhmm... where your practical knowledge increases tremendously.“ (EXP_08; 85)

Crisis management skills

In contrast to many other medical specialties where people work continuously over longer periods of time (e.g., during a surgical procedure), anesthesiologists tend to work intermittently with phases of higher workload followed by long periods of monitoring and making minor adjustments, and then sudden, unexpected emergencies: “hours of boredom – moments of terror”. As a result, the ability to manage any intraoperative crisis in a calm and efficient way is seen as a hallmark of an expert anesthesiologist by novices and experts alike.

„I believe that anesthesiology hinges on emergency situations, at least for me, somehow, yes, of course what you do every day I think that is something you can learn pretty well rather soon. But I think that a good anesthesiologist is characterized, somehow, that if something turns really bad ..uhmm.. that he can regain control.“ (NOV_03; 145)

„For me, expertise is solid if not extended knowledge, actually, yes, it has to be extended. Plus manual dexterity which might be acquired through training or not, plus experience (meaning I have been working for so many years in this specialty) plus the ability to make the decision whether a situation is critical or not. If yes, proceed with ABC, if not, stay cool. Yes, I do think that this, too, has to be part of expertise.“ (EXP_05; 102)

„But there are these stressful situations and you have to recognize that situation and then combine rather quickly, and ..uhmm.. and then act calmly, that is very important, very, very important. Many anesthesiologists are, are ... they have a polypragmatism⁴, they start to get hectic and panic, that is a very bad thing in anesthesiology. First analyze ..uhmm.. look, I don't start CPR just because the monitor doesn't show an ECG trace for several seconds, I pay attention, I watch, and wait a little bit and ..uhmm.. that is something you have learned: to be able to wait.“ (EXP_03; 89)

⁴ The verbal translation of the German „Polypragmatismus“. In German the word is used to denote an approach to a situation where a person does not have a clear plan but rather does many different things almost simultaneously in the hope that one of his measures might help.

Intuitive problem solving ('gut feeling')

Central to the understanding of expertise and being an expert is a qualitatively different approach to situation assessment and decision making than there is for novices. As mentioned above, expert decision making for novices consisted mainly in making deliberate rational steps. Not once did a novice describe expert problem solving in words that alluded to an intuitive approach or gut feeling. Similar to applying textbook knowledge to solving a clinical problem, 'expertise' was less the unconscious fabric of one's decision making but rather a kind of 'material' or checklist with which one deliberately will negotiate tasks. For experts, in contrast, the aspect of a holistic situational assessment and of an intuitive decision making was central to the understanding of how their decision making had evolved over the years.

„Basically, expertise is what you have when you can do the right thing without needing further conscious thought. Or at least when you can help in that situation. That's what I think. (...) For me, that is expertise: to somehow have mastered your specialty.“ (EXP_06; 148)

„I have made the experience, thank god, that ..ubmm.. for reasons that I actually can't tell in a particular case I had the feeling "There is something wrong here!" And to take that seriously and ..ubmm.. to let it happen ..ubmm.. on a daily basis that is characteristic for an expert, that you ... that you simply take it seriously. I guess it applies to everyone that you ..ubmm.. you should not inflate intuition, and I do believe that it has to stand up to scrutiny, but more often than not it shows us the correct way““ (EXP_01; 132)

„I believe that an expert ... certainly you have to possess profound knowledge but often, often it is simply a gut feeling you have. (...) Gut feeling is when an uneasy feeling tells you: Don't do that, or do it differently, or do it that way.“ (EXP_08; 87, 89)

There appears to be a double challenge when dealing with gut feelings. On the one hand, that voice may be rather quiet and a physician may not pay adequate attention to it.

„How do you do that? I have no clue. But something I have experienced again and again is that you have a kind of seventh sense, you have that intuition, you just didn't pay attention to it and afterwards you think: What a bummer, now the patient is doing bad and actually I had felt it before, I had sensed it, thought about that problem but then somehow postponed further considerations.“ (EXP_09; 117)

On the other hand, the interpretation and solution offered by 'gut-feeling' may not always be appropriate for a particular situation, which means one has to reflect upon your feelings before you act.

“And of course, your gut feeling can lead you astray, that's why you have to reflect upon these impressions using hard facts and established concepts but it is not that we should do without gut feeling.“ (EXP_01; 128)

While some experts were unable to describe where they thought intuition, 'gut feeling', and '7th sense' originated from, others explained them by referring to a constant subconscious comparison of current information with past experience. As one expert succinctly put it

„I simply think that I compare. Probably a lot in life is comparing something. I compare with a similar situation I already experienced or that someone told me about.“ (EXP_08; 89)

Assessing and taking risks

Patients undergoing surgery deliberately agree to taking some risk for the greater benefit of healing and recovery. As far as the anesthesiological part of perioperative risk is concerned, risks arise from a patient's health condition

as well as from the risk inherent in invasive procedures necessary for monitoring and treating the patient. While novices are well aware of the fact that their current ignorance is a constant source of risk to the patient and that avoiding risk at any cost is their current main learning objective, experts have learned over time to accept risk as integral part of patient care. For them, learning how to assess risks and how to deliberately take risks without putting the patient in unwarranted danger is central to the development of expertise in anesthesiology.

„I believe being an anesthesiologist has a lot to do with different kinds of risk assessment. In other words, you see a patient (...) and you assess the risk, you examine the patient and you decide which drugs you want to use for anesthesia or your ... you somehow carry out a risk analysis beforehand: What could possibly go wrong, what could happen and from that you decide accordingly, and you do all these things, that this, that this does not happen and you can control that and at best the patient is doing fine afterwards and he can be transferred to the recovery room or to intensive care.“ (EXP_08;17)

„Well, maybe, the, the, how should I say ... how to assess the risk involved in a certain procedure or course of action. Basically, either to say “yes, we can do that” or “Oups, well now I’ll have to be very careful!” The challenge was to learn this feat although I’m sure that there is a lot of gut feeling involved.“ (EXP_05; 41)

„Yes, and certainly you sometimes have to ..ubmm.. it is partly mere trying. There are situations, for which no recipes exist or where you can’t access these recipes in time and then you carefully have to try the one or other drug and ..ubmm.. of course you know the effects of this drug and then you will see how this will affect the patient and in this way your experience grows.“ (EXP_01; 70)

Teamwork and interdisciplinarity

From the responses given during the interviews, novices appear to be pretty much absorbed with learning the basic skills of their future profession and with orientating themselves in a constantly changing educational environment. For experts, by contrast, these issues are no longer of much concern. For them, working together as a team and working with members of other specialties and professional groups instead has gained in importance.

„And finally, one component that I had completely undervalued at the beginning is the ability ... especially in anesthesiology, because all ... because in a medical emergency ... I really undervalued that at the beginning is teamwork. You only can manage complex emergencies if you work as a team because you need the expertise of the others as well, neonatology, cardiology and so on.“ (EXP_01; 148)

This cooperation applies for situations during surgery as well as for the pre- and post-operative evaluation of patients where the anesthesiologist is tasked with negotiating the perspectives of different specialties and with finding a way to proceed with a patient’s surgery.

„Yes, and at the beginning [of my career] I definitely was unaware of the fact that the weak point of our ... well, that is almost political ... health care system is the multidisciplinary, the communication and here is I believe ... but I wasn’t aware of the fact, here anesthesiology plays a key role, because it sees things, which means the patient, at least a little bit in a coherent way and ...ubmm.. sometimes has to be an advocate for the patient with a cardiac disease in the ophthalmological department or for the child with congenital heart disease in the ENT department.“ (EXP_01; 30)

The limitations and downside of expertise

One consistent finding during the interviews was the conviction of the participants, that both, ‘expertise in anesthesiology’ and an ‘expert anesthesiologist’, were limited in scope. Participants in the peer assessment conveyed there was no such thing as “*the expert in anesthesiology*” but rather that genuine expertise was only possible in a confined area of work (e.g. expert in pediatric anesthesia, expert in regional anesthetic techniques etc.). Experts, too, shared this understanding of expertise as limited in scope. One of the two highest rated experts comments:

„Not everyone is expert everywhere. Rather, you have a certain expertise in a certain area. For example, I haven’t worked in the department of maxillofacial surgery for so many years, so I would never say that I’m expert in this area.“ (EXP_02; 122)

In addition, experts stated that they believed that expertise was not a static property of individuals which, once acquired, would last an entire professional life. They asserted that expertise had a shelf life and that experts had to continue to use their skills or else would lose their expertise.

„I do think that it’s part of expertise that you have to stay on the ball. I can hardly imagine expertise as something where you say: Well, for the next couple of years I will not concern myself with this topic; so yes, I do believe that expertise has an expiratory date.“ (EXP_01;158)

In contrast to novices who shared their perception that experts tend to become “sloppy” and have a “short-sleeved approach” to work, some experts took a more qualified view.

„For example, it really bothers me is if something, if a problem is unresolved ...ubmm.. what I mean, what is evident.. which goes beyond the fact that this is the way I earn my money (...) Well, if you want to make a negative statement then I would say that a certain complacency, I believe, would prove that an expert is not an expert after all. “ (EXP_01; 170)

Nature or nurture – what makes an expert?

A recurrent theme throughout these interviews was the question of to which extent does being an expert depends on internal qualities of a person as compared to external factors such as peer support, challenging learning opportunities, constructive feedback etc.

„Well that is actually a general question: what did you learn and what were you born with? There are many abilities that a person has and I do believe, yes, that the abilities needed in our job are personal qualities which you ..ubmm.. which you have been endowed with from birth, which you may be unable to learn. What I mean is ..ubmm.. a basic understanding of empathy, to be collegial, a certain kind of team spirit, these are all abilities you have to possess, and maybe you will be able to learn them, if you see that they are needed at work. But intuitively, you should bring them with you. (...) The technical aspects, these are things you can learn, more or less successfully. By this I mean inserting iv-lines, to puncture, to intubate, how to calculate drug dosage, the application, how to titrate drugs, any kind of technical aspect that you can learn, you actually may learn, but I believe that the basis, to be able to follow your ideals, that has a lot to do with being made out of the ‘right stuff’.“ (EXP_09; 37;39)

„Knowledge is something you can learn, that a matter of how much effort you invest, one person has to learn two hours whereas another only need half an hour. As far as practical skills are concerned, I always say that you can train them up to a certain point, but I really think that the last quantum you either have or you don't.” (EXP_05;80)

Especially one expert (EXP_09) was adamant regarding the humanistic and empathetic aspects of expertise which he thought were central to what it takes to be an expert in anesthesiology:

„I believe that those who are less expert, or less than what I believe is an expert, and who don't have these capabilities are people –that may sound a bit harsh- who have a small deficit. People who can't listen, who are unwilling to differentiate, to structure, people who don't want to be empathetic, people who don't have a genuine feeling of responsibility, and of course those who have never learned the basics of their trade. So if someone still doesn't know how much epinephrine to give during resuscitation, then he's a hopeless case. You need to have got what it takes. But I believe that it is in particular these human qualities which you have to bring to the job.“ (EXP_09; 59)

In stark contrast, when novices reflect upon the question of 'nature vs. nurture' their responses did not broach the issue of personality or social behavior but either discussed the 'nature'-part in very general terms or focused more on the personal reasons to choose anesthesiology as profession:

“I think that there are personal characteristics that someone is suitable although I actually can't say what these are ..uhmm.. which will lead to the fact that one is one of the good ones, or the better ones ..uhmm.. but certainly that is only a building block of the whole or the complex ..uhmm.. to become an expert or the ladder leading up to it.”(NOV_07;53)

“Well, part of anesthesiology is not only knowledge, and as far as knowledge is concerned I would presume that everyone can acquire it. Or everyone, who ..uhmm.. who has finished medical school can acquire the necessary knowledge ..uhmm.. I think that a certain amount of skills is part of anesthesiology and a ..uhmm.. certain kind of affinity. I don't think that everyone possesses this kind of affinity.” (NOV_08; 67)

5.8 Definition of 'expertise in anesthesiology'

At the end of the interview, every participant was asked to sum up and to define as succinctly as possible: what is expertise in anesthesiology? Some novices (NOV_03, NOV_04) found it difficult to answer the question. Other novices tried to define the term and provided an answer which appeared to be rather abstract

„It has definitely a lot to do with the experience that you can gain in your profession. I do think that it will help you to progress further.” (NOV_5; 161)

“It is, I think definitively the combination of knowledge, or the social factors which not only include empathy but also communication and so on but then again ..uhmm.. one part of them is more the personal contribution and then of course the environmental factors, which contribute and that you are capable of bringing both together.” (NOV_07;122)

The experts' answers, in contrast, appeared to reflect decades of practical experience and an intensive engagement and thought about the topic.

“If you ask me what makes an expert who can master critical situations then I would say that these are technical skills that you simply have to have, no doubt, knowledge and intuition. And collaborative skills.” (EXP_01;154)

“Well expertise in anesthesiology is certainly a ... smorgasbord of a multitude of factors; the theory you learn, what you learn during your residency, the professional knowledge, and there are a lot of technical skills you learn, that’s part of expertise as well, certainly, and to train certain processes, that is important, and then maybe also ..uhmm.. an experience, a shared experience within the team.” (EXP_02; 122)

„Basically, expertise is what you have when you can do the right thing without needing further conscious thought. Or at least when you can help in that situation. That’s what I think. (...) For me, that is expertise: to somehow have mastered your specialty.” (EXP_06; 148)

6 Results on ‘resilience’

6.1 Accounts of critical situations

During the second part of the semi-structured interviews, participants were asked to give an account of a critical situation that had been well managed and to try to list some of the aspects that contributed to the positive outcome. Novices almost exclusively reported on events which, from a medical perspective, do not fulfill the criteria of an emergency situation but which were rather daily occurrences: successfully managing intraoperative high blood pressure, solving a problem in the recovery room, successfully mask ventilating or intubating a patient, and giving anesthesia to patients.

„"A situation where we did really well was when I gave anesthesia to a young patient, he was ASA II⁵, and ..uhmm.. a general anesthesia with oral intubation together with the attending Prof. Schmitt and ..uhmm.. and surgery went well, anesthesia went well, we had no complications or problems at all and in the recovery room he told the nurse that this had been an excellent anesthesia. And in retrospect I had to agree, yes, we actually had done quite well.“ (NOV_08; 77)

Only two real emergencies were reported here and the novice either watched an expert team do an emergency C-section or where she assisted a team doing CPR on a patient in the induction room. As a general impression, novices had difficulty in naming contributing factors for the successful outcome of the situation (Table 12). Experts in contrast reported on many vital emergencies: a difficult intubation, the diagnosis of acute bronchiolitis in an infant, anesthetizing a child with mediastinal mass syndrome, and the management of a ruptured abdominal aortic aneurism. Their list of contributing factors was a bit more elaborate but still not very insightful.

⁵ The physical status classification system of the American Society of Anesthesiologists (ASA) uses five categories (I – V) to assess and communicate a patient’s pre-anesthesia medical co-morbidities. The classification system alone does not predict the perioperative risks, but used with other factors (eg, type of surgery, frailty, level of deconditioning), it can be helpful in predicting perioperative risks. ASA I is a healthy person, ASA II has mild systemic disease and ASA V is a moribund person who is not expected to survive without the operation.

Table 12: Themes dealing with reasons for the successful outcome of a critical situation (n.m.= not mentioned)

Themes	Novice	Experts
Contributing factors to the successful outcome		
• Adequate resources and teamwork	X	X
• The senior anesthesiologist had the overview over the situation	n.m.	X
• Calling for help early	X	n.m.
• Good portion of luck	n.m.	X
• Anticipation	n.m.	X
• Familiar patient	X	n.m.
• Familiar problem solving approach	n.m.	X
• Interdisciplinary communication and collaboration	n.m.	X

6.2 Monitoring, anticipation, responding, and learning

The intention of the interview study had been to use Hollnagel’s concept of the ‘four cornerstones of resilience’ as a gateway to understanding how experts and novices might experience and describe the different aspects of “resilient behavior”. Novices responded to the probing questions regarding ‘monitoring’ (Table 4) by describing situations where the vital data monitor and alarm settings alerted them to a problem. For them, monitoring had much to do with the monitors mounted on the anesthesia machine and with comparing the data displayed with internal references:

“Well, as a result of your knowledge, for example because you read it somewhere, it’s actually the case that you are well aware of the normal values, the way they should be and of course you look at your patient and you are concerned and ask yourself: is a mean arterial pressure of 80 mm Hg for a patient with coronary artery disease sufficient or not?” (EXP_01;112)

In a similar vein, anticipating the clinical deterioration of a patient was often described as a rational process based on values from the vital data monitors.

„Well you have your expectations how the values should be and then you look at the patient or at the situation you are currently dealing with and then ..uhmm.. you make yourself somehow, well then you make the decision: yes, that needs to be treated or not and I think that several factors coincide which generate the final decision.“ (NOV_01; 118 - 120)

The novice’s understanding of an expert’s anticipation was also described in these procedural terms:

„I think that there is a subconscious point in time where simply ..uhmm.. a connection is created ..uhmm.. where they then say, yes, ..uhmm.. now I have to take measures to help the patient get through the operation well, whereas someone else will recognize the nature of this situation ..uhmm.. much later.“ (NOV_07;87)

By contrast, when experts responded to the questions regarding ‘monitoring’ and anticipation’, they actually did not differentiate between both. It appeared from their responses that Hollnagel’s distinction between ‘the potential’ and ‘the critical’ (Hollnagel, 2011) was somehow artificial and that expert anesthesiologists often addressed both simultaneously. Situation assessment, perception, and interpretation seemed to be part of a holistic approach to a situation. Often, the critical information resulting from ‘monitoring’ the clinical environment was nothing the experts deliberately looked for but rather more elusive than this. Asked how he knew when a problem arose an expert for example responded

“I believe that has a lot to do with instinct, with a sensation ... well ... with gut feeling, simply a kind of gut feeling which you don’t have right away, but which you develop over the years (...) and yes, I do believe that this is part of it that you suddenly think ‘boah, things are not running the way I would expect them to do’, and that is something that

is not evident from the curves on the monitor but rather something where you suddenly have a bad gut feeling, a sensation that extends beyond the normal monitoring, yes!” (EXP_02;102)

He then carries on to explain how this vague sensation over time can develop into more tangible impressions that can help to define the nature of the situation.

“You have to have patience to wait for the things to unfold, because as I already said, it’s not that you recognize a development but rather that you have a sensation and then you have to wait and see what happens next; something that may substantiate your current feelings.” (EXP_02;106)

But not only monitoring and anticipating were described as continuous perceptual cycle, responding, too, appeared to be part of a constant situation assessment.

„One person says: I increase the oxygen and see how this will affect the patient. And the other one says: I will increase the oxygen to 100% but at the same moment when he turns the knob he is already two steps ahead with his thoughts and says: If increasing the oxygen does not bring the results hoped for, what then? So for me that is a main part of expertise. I do not play chess, but it’s like thinking ahead at least two moves.” (EXP_05; 94)

The expert’s description of effortlessly ‘being ahead of the game’ several moves contrasts with novices’ conceptualizations of experts’ fluid performance. Commenting on how she admires the effortlessness with which experts unerringly know what to do a novice ponders:

„I sometimes imagine that an expert carries a very extensive flowchart in his mind and knows: if this, than that and if this and that, than preferably this option.“ (NOV_08;93)

Finally, the strategies how novices and experts used to learn from experience, how they ‘addressed the factual’ (in Hollnagel’s terms), seemed almost identical. The only significant difference between both groups was the fact that novices did not mention other novices as people to learn from.

Table 13: Themes dealing with ‘learning’, Hollnagel’s fourth feature of resilience (n.m.= not mentioned)

Themes	Novice	Experts
My personal strategy to learn the right lessons is ...		
• ... to learn from my mistakes	X	X
• ... to reflect upon my experience	X	X
• ... to discuss my experience with peers	n.m.	X
• ... to emulate successful behavior from a colleague	X	X
• ... to consult textbooks	X	X

6.3 Results of the reflexivity process

In order to take my role as attending in the interview process into account, I decided to add an auto-ethnographic perspective to the data generated by the interviews. During the data collection period I kept a diary in which I wrote down my experiences with novices as well as personal reflections about my relationship with novices or expert colleagues and how their comments and statements from the interviews may have informed my perspective as I went forward.

For me, the most relevant realization was how difficult and complex the first months are for novices. When I did the transcriptions, I was often astonished about what constituted a problem or a major learning progress for novices: How to anesthetize a healthy young patient, how to organize all the lines and tubes connected to the patient, and how already a few monitoring devices sufficed to overwhelm them. It came as a surprise to me to

hear from the novices how difficult it was for them to arrive at the 'simplest' decisions. Hearing their personal accounts helped me to understand my daily experience in the OR, that it took them very long to perform even the 'simplest' tasks. I realized that 'simplicity' and 'complexity' are in the eye of the beholder and that over the decades of clinical practice I had forgotten all the difficulties the beginner has to cope with. Even while I did the interviews, I noticed that I was always tempted to get quickly frustrated when it took novices too long to perform even the most mundane manual tasks or when they called me again and again to clarify clinical problems. However, some comments actually challenged me. When one novice commented on the fact that once clinicians have passed a certain level of experience it is their deliberate choice whether they merely wanted to maintain their status quo or whether they wanted to continue to grow as experts I realized how easy it could be to shrink from 'going the extra mile' and opted for the easy life instead.

During one interview a novice reported how difficult it was for her to talk with the parents of children scheduled for surgery, trying to answer their questions and at the same time knowing that she actually had no practical experience to substantiate her responses. I contrasted her description with the experience I have had. When I, an attending and a clinical "silverback" with 25 years of experience talk to the parents, my seniority and age alone provides comfort and relieves anxiety even before I even start to answer their questions.

On one occasion I was tutoring a novice on how to perform a central venous catheterization. During the preparations, the novice asked me: "Do you allow me to use ultrasound [to visualize the veins in the neck]?" Because the use of ultrasound is recommended in the guidelines for this procedure the question piqued my curiosity and I asked the novice whether there actually were attendings who forbade the use of ultrasound and insisted on performing the procedure using an anatomical landmark technique only. The reason I asked was that the interviews had made me sensitive of the impact of attendings' quasi-normative rules on a novice's performance. The situation illustrated nicely the normative contradictions novices often have to resolve: official guidelines recommend using ultrasound, but the decisive factor is the attending's preference.

Finally, during the interviews there was one novice who gave me the impression that she had the feeling that I was examining her and trying to tease out her theoretical knowledge about 'expertise'. During the interview, she repeatedly asked me: "Is this what you wanted to hear?" This experience made me wonder whether issues of power might have influenced the responses of the other novices as well.

7 Discussion

In this study, a group of nine novices from a German university hospital with a mean clinical experience of 4.3 months were interviewed about their understanding of ‘expertise in anesthesiology’ and ‘resilience in anesthesiology’. Their responses were contrasted with the perspectives of nine expert anesthesiologists averaging 26.7 years of professional activity in anesthesiology.

The findings about how both groups conceptualize and understand the task requirements of an anesthesiologist are comparable to those published previously (Klemola & Norros, 1997; Larsson et al., 2003; Smith, Goodwin, Mort, & Pope, 2004). The responses given confirm the view that anesthesiology is a profession with a strong scientific basis in applied physiology and pharmacology that allows it to be a broad-based acute care specialty. Furthermore, it has a strong technical component and a more or less circumscribed but intense physician-patient relationship that is therapeutically goal-driven (Wong, 2011). The reasons for novices to select anesthesiology as a career were a) the clinical application of physiology and pharmacology, b) the immediate gratification of one’s work, c) the ability to perform invasive procedures, and d) a collegial work environment that allows to balance work and private life. These reasons for choosing anesthesiology have been reported previously (Wass et al., 2001). For novices, who had just finished medical school and who carried the responsibility for a patient for the first time, the efficacy and dynamics of administering anesthetic drugs was a salient feature of their new profession. The fascination of instantaneously putting people asleep was no longer remembered by the expert group. In their memory, the scope of learning as novices manual skills prevailed.

7.1 Complexity - the forgotten challenge

However, the experts’ description of being novice and learning manual skills lacked any allusions to possible difficulties learning these skills. In contrast, novices were able to share their limitations and frustration concerning skill acquisition. The unfamiliarity with routine tasks in new environments as well as situations requiring multitasking easily can bring them to their limits. Experts, though, have no recollection of complexity as a major challenge during the first months of their residency training. They do remember and talk about strong emotions from that time (e.g., anxiety, excitement, being thrown into the deep) but not about how daily events easily had brought them to their limits. This discrepancy between what novices experience and what experts are able to remember may not only be the result of mere forgetfulness on behalf of the experts but rather of the preponderance of readily available knowledge about current performance over their own former learning experience (“availability heuristic”; Hinds, 1999). With long term experience the expert is one who is able to bring more and more of his or her world into the realm of the familiar (Feltovich, 1997). As people become more expert, they automate manual tasks and develop an oversimplified view of the task so the details of the task become less salient. As a result, experts may have difficulty understanding the challenges faced by novices when trying to learn a new task, even when reminded of these challenges. This observation is certainly true for me: as stated earlier, my diary entries reminded me of the fact, that I, too, was often tempted to become impatient with the performance of novices whenever I had the feeling that it took them far too long to perform even mundane

manual tasks. Quite obviously, I too, have forgotten about how difficult it had been for me to learn and to master these skills.

7.2 It's obviously not obvious - identifying experts

Already the peer assessment process prior to the interviews illustrates two aspects of expertise that have been discussed in literature.

First, the general understanding of the respondents was that there can be no such thing as “the expert in anesthesiology” with a very broad and comprehensive expertise in all domains of anesthesiology. Rather, they took the view that anesthesiology is a multi-faceted profession, requiring multiple expertises and that an individual can only be expert in one or two areas but not in the entire specialty of anesthesiology. This position taken by peers is in accordance with research on expertise, where the fact that professionals may exhibit genuine expertise in some of their activities but not in others has been referred to as “fractionated experience” (Kahneman & Klein, 2009). Because in most domains professionals will have to deal with situations and tasks that they have not had an opportunity to master, it is believed that the fractionation is the rule rather than an exception. The reason is that in order to become an expert, professionals need to be constantly exposed to a “high-validity” task environment with a stable relationship between cues and events: outcomes of actions have to be predictable, good feedback has to be available and people have to spend considerable time in an environment to gain sufficient experience (Shanteau, 1992a). The first two of these criteria are met by anesthesiology, where routine events as well as acute crises follow the laws of physiology, pharmacology, and physics. The requirement of a steady exposure to a certain work environment can help explain the interviewees’ position, that expertise in specific areas has a ‘shelf-life’ and an ‘expiry date’: If professionals have not worked in a certain area for a considerable amount of time, the memory of feedback will fade over time and expertise will start to decrease (‘use it, or lose it’).

The second observation was that the results of the peer rating process suggested that expertise is not a monolithic feature, readily recognizable to every member of a social group, but rather highly individualistic. The ratings of physician and nurse peers resulted in a considerable number of individuals that were considered to be experts (Figure 1) rather than in a limited list of a few individuals everyone naturally agreed upon. In addition, the three youngest experts chosen were astonished to learn that their nurse and physician peers had rated them as experts. Finally, when going through the list I, too, was astonished about the choices my peers had made: I would not have considered several of the colleagues as being an expert. All these aspects together could reflect the often-overlooked sociological dimension of expertise: People are experts not just because of what they know and how they perform, but because of what their social environment, what other team members, think they know (Carr, 2010).

7.3 Expertise is not yet a concern – learning the basics is

The interviews were intended among others to answer the research question of what novices think ‘expertise’ might entail. Novice anesthesiologists with less than half a year of clinical experience had considerable difficulties in answering the question. For some of them, the question was definitively too early, as they had never actually spent much time thinking about it. Others novices, by contrast, tried to define the concept but only managed to do so in very general and theoretical terms. We can conclude from the responses our novices gave that novices actually don’t deal with the same problems as researchers when it comes to understanding ‘expertise’. They struggle with very basic issues like translating theoretical knowledge into meaningful and appropriate action and acquiring vital skills but do not bother understanding expertise: either in these terms or it is simply not yet a concern.

The struggle of learning the basics was not a topic explicitly mentioned by experts but rather a theme underlying descriptions of ‘being thrown into the deep’ during the first months at work. The explicit responses that experts gave about their time as novice can be subsumed under two broad headings: ‘mastering skills’ and ‘finding one’s own way’ (see Table 7). ‘Finding one’s own way’, developing independent personal routines, is a goal that goes beyond merely learning the basics. Whereas ‘learning the basics’ entails applying theoretical knowledge in combination with local standard procedures to anesthetize a patient, ‘finding one’s own way’ presupposes experience that has helped the clinician to develop a preferred, individualist way of working (Smith et al., 2003).

7.4 You can’t leave your comfort zone if you haven’t found one yet – becoming expert

The almost complete lack of concern for developing expertise is also reflected in the novices’ responses about what they can contribute to becoming an expert (Table 7). They were well aware of the fact that they had to acquire theoretical knowledge and that they needed a supportive environment in order to make progress, but with the exception of one novice the issue of ‘leaving your comfort zone’ was never raised. The relative absence of this theme from the novices’ perspective is in clear contrast to the experts’ statements, where issues around ‘leaving your comfort zone’ were central to their self-understanding of experts. However, ‘leaving your comfort zone’, deliberately practicing skills, actively engaging with new and difficult situations, and investing additional effort and time to actively enlarge the repertoire of situations mastered might only become possible once a solid basis of clinical experience exists on which one can build on.

While novices and experts both agreed that staying motivated and accepting your limits were a constant challenge, only experts commented on the difficulties with the interpersonal and social dimension of interdisciplinary patient care: The operating room is the place where different specialties with different agendas and priorities meet and where they try to pursue a common goal: restoring the patient’s health. In contrast to novices, experts have learned to situate this task in the broader socio-economic context of modern healthcare systems with the necessity to accept and manage risks (Vincent & Amalberti, 2016) and to balance safety and economic pressure, even if they seldom use these last two terms in reference to expertise..

7.5 Novices need experts and experts need the other – the social nature of expertise

A common understanding shared by basically every novice and expert was that the development of expertise is not an individualistic endeavor but also rather socially embedded process. Expertise can only be acquired in an environment where clinical mentors and teachers exist that are willing to share their knowledge and where peer discussions are possible without fear of being ridiculed. Novices were very much aware of the fact that in anesthesiology, like in most domains, the first important step toward mastery is learning how things work, in particular how the physiology of the patient as well as the clinical environment reward various possible actions. Learning the rules from experience (i.e., through trial and error) is potentially slower and less “economical” than learning from a mentor, who can distil personal experience and training (Weiss & Shanteau, 2014). “The acquisition of nearly every expertise, if not all of them, depends on the acquisition of the tacit knowledge pertaining to the expert domain in question. Tacit knowledge can be acquired only by immersion in the society of those who already possess it. Therefore, the process (...) depends on becoming socially embedded in the appropriate groups of experts so that one can acquire ‘specialist tacit knowledge’. For several experts, this process of understand things that one could not do and understand before was related to the person of their mentors who had helped them to unlock some of the mysteries of daily professional work during the first months. While some individuals still knew the names of and had vivid memories about their mentors, no novice gave a special mention to a certain mentor. This could be explained by the fact that novices still were in the transitional phase from medical student to active clinician and had not yet arrived at a developmental stage where they were capable of looking back to their beginnings.

Another aspect of the social nature of expertise shared across both groups was the understanding that expertise in anesthesiology is a teamwork endeavor. For the anesthesiologist, to perform on an expert level, it is not sufficient to have mastered critical skills and to possess relevant knowledge. Rather, the anesthesiologist also has to interact on an interdisciplinary level with a range of clinical partners and at the same time has to structure and lead the anesthetic team. The understanding that teamwork constitutes one of the key requirement in today’s multidisciplinary healthcare system was not present in the novices’ response but appears to develop over the years with increasing responsibility:

„And finally, one component that I had completely undervalued at the beginning is the ability ... especially in anesthesiology, because all ... because in a medical emergency ... I really undervalued that at the beginning is teamwork. You only can manage complex emergencies if you work as a team because you need the expertise of the others as well, neonatology, cardiology and so on.“ (EXP_01; 148)

The teamwork dimension not only includes the expert’s communication with and leadership of the team, but also the team’s support of the expert, especially if he or she find themselves at the edge of their competence. It was a shared understanding of both groups of interviewees that every expertise will reach its limits and that it might be a challenge for the expert to accept these limitations and ask for help. Help-seeking behavior may differ between novices and experts in at least two ways. First, it might be easier for novices than for experts to ask for help because no social expectancies exist that they should be able to cope with the respective situation on their own. In contrast to studies on help-seeking behavior in surgeons (Novick, Lingard, & Cristancho, 2015), the aspect of calling for help as a threat to the expert’s image, autonomy, and development as independent

practitioner was not mentioned by our experts. On the other hand, experts may find it easier to call for help as they can choose whom to call for help, whereas trainees must call their supervisor. The choice to call may be critical one, because novices may have a problematic relationship with their current supervisor and experts, in contrast, may call another expert often with whom they have been friends with for decades.

7.6 Different challenges: experience, standards, and quasi-normative rules

In safety science, there appear to be two contrasting ways of thinking about rules and standards, and what their functions, strengths and limitations are (Hale & Borys, 2013): One model is rationalist and prescriptive in its approach and sees rules as the embodiment of the best possible way of carrying out activities, covering all known contingencies. Interestingly, several novices appeared to think that this perspective was true, that standards were specific enough to actually address every clinical contingency and that following written procedures would guarantee safety. If discrepancies between rules and reality arose, this would then be due to the fact that the rules were at the time incomplete.

„Create safety by violating standards? Hmm, actually that sounds a bit contradictory, because it's the standards that should give you safety. Well, I guess in that case the standards are not elaborated enough, because normally, they should ..uhmm.. yes, specify how to do the work.“ (NOV_02; 125)

This perspective on explicit knowledge certainly gives the novice the necessary feeling of security essential for gaining confidence in one's own clinical abilities (Eisenach, 2009b). Expert anesthesiologists, by contrast, took another view: rules and standards could never be complete and the written ones were seen as essentially underspecified, requiring experience and expertise to translate them before application to any given, specific situation (Hale & Borys, 2013). They are underspecified because they are about populations whereas physicians have to treat individual patients. The variability of diseases and patients and the interactions across patient conditions spill over the category boundaries of best-practice guidance. In addition, the scientific evidence presented in guidelines and recommendations does not speak for itself but needs to be interpreted, revised, and tailored to specific contexts and conditions, all of which takes expertise (Klein, Woods, Klein, & Perry, 2016). As a result, experts believed that one could actually improve system safety in emergency situations by not following rules if this was coupled with a valid mental model or social understanding or both of the situation (Besnard & Greathead, 2003). As one of the experts succinctly put it:

„It could be that you don't meet the standard, but you may more than meet the requirements of the situation.“ (EXP_07; 119)

When asked to comment about the relationship between evidence-based medicine (EBM) standards and personal experience, experts commented on the challenges they encountered when trying to negotiate both. Klein et al. recently identified six challenges here (Klein et al., 2016) of which four were mentioned by our experts as well: Gauging confidence in the evidence, deciding what to do when the generally accepted best practices conflict with professional expertise, applying simple rules to complex situations, and considering remedies that are not best practices (corresponding to challenges 2,3,4,6 of the original paper). As the publication focusses on the challenges expert clinicians face, it confirms the underlying assumption of this thesis, that

novices' perspectives are an untapped source of information and may provide valuable additional insight into clinical work: In this case it is the clinically relevant perception of novices that evidence-based or institutional standards often play a subordinate role to the quasi-normative rules (Bosk, 2003) attendings have established. For experts, experience may occasionally trump EBM-based rules. For novices, however, quasi-normative rules always trump EBM-based rules.

7.7 You can't describe what you haven't experienced yet – tacit knowledge and intuitive decision making

Intimately connected with the issue of cognitive challenges is the question about the knowledge with which the conflict between rules and experience is negotiated. As explained in the introduction (see Ch. 2.3), two different representations of knowledge exist. A central premise of theoretical and empirical research about expertise is that the level of tacit knowledge acquired distinguishes 'experts' from 'novices' and that the development of tacit knowledge as well as of intuitive decision making requires having spent considerable time in a "high-validity" task environment with a predictable relationship between cues and events and good feedback (Shanteau, 1992a). As a result, tacit knowledge is developed through having experienced many similar cases over time and intuition ("gut feeling", "7th sense") develops not as the result of a random or mystical process, but of pattern matching in a reasonably stable environment (Klein et al., 2016). Intuition is the recognition of valid cues even if the person is unable to state what the cues are. Given the fact that the novices had only recently finished medical school and had on average 4 months of clinical experience at the time of the interview, it does not come as a surprise that their responses did not reveal any understanding of tacit knowledge or intuitive ("gut feeling") decision making. Instead, novices conceptualized decision making as a very rational, conscious, and deliberate step-by-step process. The explanations they used were those of an active chain of thought, of a deliberate process of similarity matching, and of carrying something like a flow-chart in your mind (see Ch. 5.6). This observation may simply reflect the fact that a person cannot imagine, let alone conceptualize an experience he or she has not yet had. Instead, similarity matching and representativeness favor current and familiar experiences as the basis for understanding. In the case of recently graduated medical students this basis most probably is further validated by hypothetico-deductive reasoning taught and prioritized in higher education.

Experts, in contrast, knew exactly how intuitive decision making feels and as a result were often able to talk about it. The terms they used for this experience were "intuition", "gut feeling", and "7th sense". These terms were used interchangeably, so it appears as if they all carried the same connotation. The concept of intuition was vital to the experts' understanding of how they arrived at decisions.

„I guess it applies to everyone that you ..uhmm.. you should not inflate intuition, and I do believe that it has to stand up to scrutiny, but more often than not it shows us the correct way.” (EXP_01; 132)

Experts also appeared to be well aware of the fact that there is no subjective marker that distinguishes correct intuitions from intuitions that are produced by highly imperfect heuristics (Kahneman & Klein, 2009; p.519)

As a result, several of them reported that they checked their intuitions with conscious deliberation before acting upon the first. This approach has been termed ‘informed intuitions’ in the literature on decision making (Klein et al., 2016). In addition, some experts were explicit on the necessity to deliberately stop for a moment and to reflect upon any idea that would come to one’s mind before acting upon. This strategy illustrates the assertion found in the literature that while most expert performance is ongoing and unreflective, the best of experts, when time permits, think before they act (Dreyfus & Dreyfus, 2005).

7.8 “Nature versus nurture” – The stuff expert anesthesiologists are made of

The nature versus nurture debates are among the oldest in psychology, and the emergent conclusion is that both matter and they interact (Weiss & Shanteau, 2014). In the interviews, the question of to which extent becoming an expert depended on internal qualities of a person as compared to external factors (e.g. peer support, challenging learning opportunities, constructive feedback etc.) was answered differently by both groups. Experts agreed on the perspective that a good anesthesiologist is indeed made out of ‘the right stuff’ and has all the qualities required for this specialty. When novices reflected upon the question of ‘nature vs. nurture’ they either thematized the ‘nature’-part in very general terms or focused more on the reasons to choose anesthesiology as profession rather than on personal or innate characteristics. Several reasons might explain this discrepancy. First, novices might not know what the ‘right stuff’ actually might be, considering the many challenges they face daily. In addition, novices might feel reluctant to ascribe these ‘right stuff’-qualities to themselves in the context of the interview with one of their attendings, fearing that this might across as an arrogant statement. Several experts, by contrast, told stories about former colleagues who in their perspective had clearly lacked the qualities needed for an anesthesiologist. These repeated experiences had shaped their belief that “the final quantum” needed is something the person has to bring to the job. However, other interpretations are also possible: the interviewees had been assessed by their peers as being expert anesthesiologists. Claiming that the ‘right stuff’ is needed would imply that the respondent himself fulfills this qualification. Finally, attribution theory states that when people talk about themselves, they assign the cause of positive behavior to dispositional attributes and the cause of negative behavior to situational influences (Jones & Harris, 1967).

7.9 Resilience in anesthesiology

The second part of the thesis with the focus on ‘resilience’ was based on the three assumptions that a) the work of the anesthesiologist could and should be described in a meaningful way by referring to the concept of ‘resilience’, that b) Hollnagel’s concept of the four cornerstones of resilience, used as structure for the interviews, actually provided an adequate approach to tease out relevant information, and that c) ‘resilience’ was a theme one could realistically expect novices to talk about. At the time of the thesis proposal I took these assumptions for granted, not least because a wealth of literature from healthcare and a few publications within anesthesiology had referred to ‘resilience’ and ‘resilient behavior’ and because the author of the ‘four cornerstones’ was the renowned safety scholar Eric Hollnagel. However, several months and a series of interviews later I now doubt

that these assumptions were valid. To begin with the novices' perspective, the identification of 'resilient behavior' presupposes some kind of clinical experience to talk about. I now realize that I had worked on the assumption that novices actually had some relevant clinical experience. Maybe the results of the study would have been different had we chosen residents with one year of clinical experience, but for the cohort of this study with a mean clinical experience of 4 months the questions were not yet relevant. Doubts about the validity of my assumptions started to arise after the first interviews because the questions chosen did not appear to reveal any relevant or new information, only descriptions of routine patient care. Returning to the literature, this time with a much more critical stance provided me with a new perspective on the validity and value of the concepts of 'resilient behavior' and 'resilience in anesthesiology'.

7.10 The quest for resilience – a moving target?

Prior to the first symposium on resilience engineering held in Söderköping in 2004, 'resilience' was not a hot topic in safety science. Today, fifteen years later, the situation has changed and 'resilience' as a label has become one of the buzz-words in safety science as well as in health care. However, "with popularity has come noise and confusion as the label continues to be used in multiple, diverse and, sometimes, incompatible ways". (Woods, 2017; p.52). In its original and literal sense, resilience is derived from the Latin verb 'resilire' (prefix re- = back, silire = to bounce) and means to 'bounce back'. Consequently, the common use of the resilience concept relates to the ability of an entity, individuals, community, or system to return to normal condition or functioning after the occurrence of an event that disturbs its state (Wiig & Fahlbruch, 2019). This definition of resilience as 'rebound' has been expanded to include aspects such as robustness, graceful extensibility and the ability to adapt to future surprises (Woods, 2015). To complicate the understanding of resilience even more, Eric Hollnagel has changed his definition several times over the years. The 2006 definition of resilience as "the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state which allows it to continue operations after a major mishap in the presence of a continuous stressor" has now changed into "resilience is an expression of how people, alone or together, cope with everyday situations-large and small-by adjusting their performance to the conditions"(Hollnagel, 2018; p.14). So, resilience is now no longer about how organizations remain safe or return to a safe state but about how they perform in general. In a similar vein, Hollnagel's four cornerstones actually describe the way basically every living organism tries to orientate itself in the environment: to anticipate threats, to react to external stimuli, and to learn from experience. There is no doubt that all the features Hollnagel describes are valuable and necessary for organizations to thrive and survive. For me, the question is how far a definition can become detached from its original meaning until it loses any relevance. If 'resilire' means 'to jump back', why include all kind of characteristics that have no longer anything to do with the original meaning, into the concept?

7.11 Old vine in new clothes – non-technical skills and resilient behavior

In a similar vein, the notion of 'resilient behavior' can be critiqued in two ways. First, safety scholars like Westrum and Woods connect resilience with the ability to recognize, absorb and adapt to disruptions that fall

outside a system’s design base. Some disruptions and threats are well within the systems design base (‘regular threats’ in Westrum’s terminology) as it is the case with anesthesiology and intraoperative emergencies. For these ‘designed-for uncertainties’ (in Wood’s terminology) a textbook performance envelope exists that is taught and trained during the professional formation of an anesthesiologist. As a result, referring to the crisis management of intraoperative emergencies as ‘resilient behavior’ (Cuvelier & Falzon, 2011) actually misreads ‘resilience’. In short, what anesthetists seem to have reported as the four cornerstones actually defines normal acute medical care.

Second, to confine ‘resilience’ to ‘resilient behavior’ actually ignores the fact that resilience is a system property that emerges from the interactions at the micro/meso/and macro level. As a result, behavior can only be described as ‘resilient’ if the other system levels from teams, organizations, regulatory bodies, and policy levels are taken into account that influence and enable (or hinder) human performance (Bergström et al., 2015; Wiig & Fahlbruch, 2019). Unfortunately, this is not the way how the anesthesia-related literature has conceptualized resilience (Table 14).

Table 14: Conceptualization of ‘resilience’ in all publications identified within the anesthesiological literature. Note the differing definitions of resilience as either a system quality or as an individual behavior.

Reference	Conceptualization of ‘resilience’
A. F. Smith & Plunkett, 2018	“Resilience can be defined as the everyday performance variability that provides the adaptations that are needed to produce good outcomes, both when conditions are favorable and when they are not.”
Cuvelier & Falzon, 2008, 2011	“Resilience are the different strategies used by anesthesiologists to avoid the negative consequences of the variability of everyday work.”
Falegnami et al., 2018	“The resilient organization should possess four cardinal abilities, or cornerstones—to learn from past experiences, to monitor its own state and that of the environment in which it is located, to anticipate events, and to respond adequately—until it can cope as effectively as possible in situations that have never occurred before.”
Prielipp & Birnbach, 2016	“Resilience has been defined as the intrinsic ability of a system to adjust to its functioning before, during, or after changes and disturbances so that it can sustain required operations, even after a major mishap or in the presence of continuous stress.”
Staender, 2015	“Resilience is defined as the system’s ability to sustain required operations in both expected and unexpected conditions.”
Schnittker & Marshall, 2015	“Another way of approaching safety is to determine why things went well. This approach of strengthening safe practices is termed ‘resilience’. Resilience describes the property of being flexible, robust, and elastic. In high-reliability organizations, this translates to an ability to ‘respond to sudden, unanticipated demands for performance and then return to normal operating condition quickly and with a minimum decrement in performance.’”

Returning to my initial assumption, that Hollnagel’s four cornerstones were a helpful venue into understanding ‘resilience in anesthesiology’ I now would say that they are ‘old vine in new clothes’, a new label for other, well-established concepts in anesthesiology. For example, the four cornerstones of resilient behavior can easily be retrieved from the four skill categories and fifteen skill elements of the “Anesthesia Non-Technical System” (“ANTS”; Fletcher et al., 2003; Flin, Glavin, Maran, & Patey, 2003), a behavioral marker system for effective performance in everyday tasks and emergency situations in anesthesiology. Like ‘resilient behavior’ the non-technical skills identified in these behavioral marker systems are not confined to crisis management skills but include monitoring, anticipation, and learning strategies as well.

Table 15: Comparison of the four cornerstones of resilient behavior (left; Hollnagel, 2011) with ANTS, an established behavioral marker system for effective performance in everyday tasks and emergency situations in anesthesiology (right; Flin et al. 2003). The four different colors highlight identical concepts in both systems. Hollnagel’s four cornerstones and ANTS show almost complete conceptual overlap.

Cornerstone	Definition	Category	Elements
Anticipation	Knowing what to expect, or being able to anticipate developments, threats, and opportunities further into the future, such as potential disruptions or changing operating conditions. This is the capability to address the potential.	Task Management	<ul style="list-style-type: none"> • Planning and preparing • Prioritizing • Providing and maintaining standards • Identifying and utilizing resources
Monitoring	Knowing what to look for, or being able to monitor that which changes, or may change, so much in the near term that it will require a response. The monitoring must cover the system’s own performance as well as changes in the environment. This is the capability to address the critical.	Team Working	<ul style="list-style-type: none"> • Coordinating activities with team • Exchanging information • Using authority and assertiveness • Assessing capabilities • Supporting others
Responding	Knowing what to do, or being able to respond to regular and irregular variability, disturbances, and opportunities either by adjusting the way things are done or by activating ready-made responses. This is the capability to address the actual.	Situation Awareness	<ul style="list-style-type: none"> • Gathering information • Recognizing and understanding • Anticipating
Learning	Knowing what has happened, or being able to learn from experience, in particular to learn the right lessons from the right experience. This is the capability to address the factual.	Decision Making	<ul style="list-style-type: none"> • Identifying options • Balancing risks and selecting options • Re-evaluating

The final research questions of this thesis was whether expert physicians describe part of their expertise with vocabulary comparable to the one used in resilience engineering. Given the fact that the interview data on ‘resilience’ yielded limited results and that the resilience factors mentioned by the interviewers were rather trivial (e.g., “call for help” as a resilient strategy) it is concluded that there is no intersecting set of resilience engineering vocabulary shared by both professions. The results of this interview study can be interpreted as that novice and expert anesthesiologists do not "do" much with our languages of safety. Their description of how they manage their daily work differs considerably from the conceptualization and vocabulary of resilience safety scientists are familiar with. This conceptual gap could imply that safety scientists are in danger of talking about every day skilled work in a way that experts would find difficult to recognize.

8 Limitations

The limitations to this study are identical to those of any qualitative interview study based on a small number of participants (Britten, 2006; Gallo, Murphy, Braga, Farrokhyar, & Thoma, 2018; Ripley, 2007). While qualitative studies can have high validity by providing in-depth understanding of a phenomenon, generalizability or transferability of the study results to other contexts can often be limited. The interview was performed at one location and data has been collected from employees at the Department of Anesthesiology at one German University hospital. Therefore, the responses of the participants are not necessarily reflective of anesthesiologists practicing in other university hospitals or in other parts of Germany or elsewhere. It follows that the findings may not generalize to other medical settings but reflect the organizational culture and structure of a particular hospital. The convenience sample size of 9 novices and 9 attendings may not have allowed for data saturation. It follows that increasing the number of interviews might have strengthened the results of the study. Further, the investigator is a colleague and in the case of the novices, sometimes a direct supervisor and this may have affected the responses in a negative or positive way. That is, junior participants may have felt compelled to

respond in a more socially acceptable fashion rather than free to provide a true reflection of their opinions. On the other hand, as the interviewer has worked with many of the experts it is possible that this may affected the openness of the verbal exchange, hopefully in a positive way.

9 Conclusions

In this interview study, which set out to compare novices' and experts' perspective on 'expertise in anesthesiology' and 'resilience in anesthesiology' I was able to detect shared understandings as well as divergent conceptualizations in the responses given. Both groups understood the work characteristics and task requirements of an anesthesiologist in an almost identical way. During the peer assessment process, it became apparent that expertise was not a monolithic feature, readily recognizable to every member of our department, but rather a highly individualistic assessment. The respondents took the view there can be no such thing as "the expert in anesthesiology" because anesthesiology is a multi-faceted profession, requiring multiple expertise. Novice anesthesiologists with a mean clinical experience of 4.3 months found it difficult to talk about or define expertise. They struggled with very basic issues like translating theoretical knowledge into meaningful and appropriate action and acquiring vital skills but did not bother understanding expertise because it was not yet a concern for them.

The interviews revealed how the complexity of routine tasks in new environments as well as situations requiring multitasking easily brought novices to their limits. Experts, it appears, had no recollection of complexity as a major challenge during the first months of their residency training. A common understanding shared by novices and experts was that the development of expertise is not an individualistic endeavor but rather a socially embedded process. Expertise can only be acquired in an environment where clinical mentors and teachers exist that are willing to share their knowledge. Novices appeared to believe that written standards were specific enough to addresses every clinical contingency and that following written procedures would guarantee safety. Expert anesthesiologists took the view that rules and standards were essentially underspecified, requiring experience and expertise to translate and adapt them before application to any given, specific situation. While experts were able to describe how they negotiated standards and recommendations with clinical experience, novices saw that evidence-based or institutional standards played a subordinate role to the quasi-normative rules attendings expected to be followed. The way novices portrayed decision making did not reveal any understanding of tacit knowledge or intuitive ("gut feeling") decision making. Instead, they conceptualized decision making as a very rational, conscious, and deliberate step-by-step process. Experts, in contrast, were able to describe intuitive decision making and used terms like "intuition", "gut feeling", and "7th sense".

The increasing interest of safety scientists to understand safety by applying the concept of resilience is hampered by the fact that the term is used in multiple, diverse and, sometimes, incompatible ways. Anesthesiology as a work context is no exception to this rule and it appears as if the notion of 'resilient behavior in anesthesiology' is actually a relabeling of some non-technical skills (e.g. ANTS). In addition, the way it is often used in the anesthesiological literature ignores the fact that resilience is a system property that emerges from the interactions

at the micro/meso/and macro level. Given all this, it is questionable whether this re-labeling will create any new insight into the practice of anaesthesia.

10 References

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