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ABOUT COVER

Dr. Rakhshan is an editorial board member of *World Journal of Meta-Analysis*, and a former lecturer in the Dental School of Islamic Azad University, Tehran, Iran. He graduated from the same university in 2004, with a DDS thesis in which he designed and implemented an AI computer vision program that could extract radiographic landmarks from lateral cephalographs. Since then, besides clinical practice, he has taught dental anatomy and morphology, and has published about 140 peer-reviewed articles on different dentistry topics. He has also peer reviewed more than 500 articles during these years, and has been the lead guest editor of the journals *Pain Research and Management*, *Computational Intelligence and Neuroscience*, and *International Journal of Dentistry*, and an associate editor of *Frontiers in Oral Health*. He is currently a PhD candidate of cognitive neuroscience at the Institute for Cognitive Science Studies, Tehran, Iran

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Learning and competence development *via* clinical cases – what elements should be investigated to best train good medical doctors?

Henriette Löffler-Stastka, Guoruey Wong

ORCID number: Henriette Löffler-Stastka [0000-0001-8757-0435](https://orcid.org/0000-0001-8757-0435).

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Henriette Löffler-Stastka, Department of Psychoanalysis and Psychotherapy, and Postgraduate Unit, Teaching Center, Medical University of Vienna, Vienna 1090, Austria

Guoruey Wong, Faculté de Médecine, Université de Montréal, Montréal H3T 1J4, Quebec, Canada

Corresponding author: Henriette Löffler-Stastka, MD, Associate Professor, Dean, Department of Psychoanalysis and Psychotherapy and Postgraduate Unit, Teaching Center, Medical University of Vienna, Währinger Gürtel 18-20, Vienna 1090, Austria.

henriette.loeffler.stastka@meduniwien.ac.at

Abstract

In European higher education, application of information technology, concentration on the learning-processes, consistent implementation, transfer learning, case-based learning, autonomous learning has been extensively studied in the last decade. Educational sciences based on neuroscientific findings use brain-based learning and teaching, including integrated thematic instructions and emotion-theory. Elements essential to this strategy, such as theory and methods for learning, competencies, attitudes, social reality, and a metadiscourse are described herein. Research on learning tends to focus on declarative knowledge, associative learning with conditional stimuli, and procedural knowledge with polythematic/crosslinking thinking. Research on competencies: In research on competencies (*e.g.*, for clinical reasoning, decision-making), intuitive and analytical components are studied. As repeated presentation and exercising of clinical cases is crucial for an efficient learning process, the implementation of interactive scenarios including affectively involving didactics is considered. For competence-development observational methods, questionnaires/item sets or factors have to be targeted and empirically validated. Attitudes and social reality: Clinical decision-making, identification processes and attitudes (“Hidden curriculum”), as well as secondary socialization processes (integration of social norms, values, preparation of role-acquisition, occupational role) are studied *via* process research, conceptual research, and observational methods. With respect to social reality research, conscious and unconscious bargaining processes have to be taken into account. Methodology: Neuroscience – memory, neuronal, molecular biology, and computer science (Neurocircuits) are integrated into observational process research (*e.g.*, affective-cognitive interface, identification processes) and conceptual research is added and studied on the meta-level, including discussion

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of research paradigms. This discussion provides ongoing feedback to projects in a hermeneutic circle.

Key words: Social neuroscience; Case-based learning; Mixed-method design; Hidden curriculum; Socialization; Research

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Core tip: Consequent application of evidence based didactics based on social neuroscientific findings is necessary to develop good medical doctors and therapeutic professionals. An overview of the higher education history and development throughout the past decades is given. An up to date description of the current knowledge regarding higher education and research strategies to enhance the evidence-based components to optimize teaching and learning are proposed.

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INTRODUCTION

For a long time, educational sciences were grounded in neuroscience, whereas “Neurodidactics” were based on computer/mathematical models^[1,2]. Constructivist-didactic perspectives called for revision of such archaic positions and research paradigms, stating that controlled intervention cannot be possible^[2,3] nor be studied reliably, as the trajectory and outcome of learning processes are not assessable^[2,4]. The next great shift in research methodology involved the expansion of the descriptive and interpretative perspectives^[2,5], which was suggested in order to adequately investigate gains in acquisition of knowledge. As a result, the utility of Brain-Based Learning and Teaching^[6], along with Integrated Thematic Instructions^[7] (including Emotion-Theory) were researched in the context of European higher education.

In parallel with discussions on adequate research methodology, the learning context was refined, and applied research in the domain led to several new strategies in European Higher Education. First, the Declaration of Prague (2001)^[8] suggested the application of Information- and Communication-Technology. Later, it was recommended that a focus on the learning-processes (Declaration of Leuven 2009)^[9] should take place and that research should be implemented consistently (Declaration of Vienna-Budapest 2010)^[10]. In the Lancet Report (2010)^[11], a lack of research on Transfer-Learning was stated, and so as a result, Case-based learning (CBL) together with workplace-based assessment was implemented. With growing evidence for the applicability and advantages of CBL, several subsequent efforts focused on autonomous learning, leading to the LLL-Strategy (Lifelong Learning). In general, with respect to research methodology, once again the basis of Educational sciences was firmly and prominently grounded in neuroscientific findings^[12].

We support the claim that brain-based learning and teaching^[6] using integrated thematic instructions^[7] has to include Emotion-Theory, and should not exclude the constructivist perspective of taking the learning environment into account^[13].

For this strategy to work, we need to concentrate theoretical underpinnings and research in the following areas: Learning, competencies, attitudes, social reality, and inclusion of a Metadiscourse.

THEORETICAL CONSIDERATIONS

Learning

Learning and competence development is based on research according to the research paradigm of the educational sciences and neurosciences, including social neurosciences.

Declarative knowledge: Declarative knowledge has to be acquired concerning basic facts that include knowledge which is available and can be accessed on the conscious level, and in general is stored as unconscious knowledge in long-term memory. Teaching and learning etiological concepts to understand basic principles of specific domains is therefore bound to conscious and unconscious mechanisms.

Associative learning: In this type of learning, the temporal relationship of the two stimuli has to be recognized: The person responds to the first stimulus in anticipation of the second (a neural link/association is its foundation). The result of the reclassification of stimuli and responses are drives (conditional appetite, conditional action, conditional aversion, and/or conditioned inhibition). Associative learning is the fundamental basis of memory.

Procedural knowledge: To attain, train, foster, and confirm procedural knowledge, poly-thematic crosslinking thinking first has to take place: The ability to link information (thoughts, symbols, images, scenes) in a meaningful way and to know how to master this information has to be followed by creatively linking and combining previously seemingly unrelated areas (domains) with each other. The result is to attain the competence *e.g.*, to write a novel instead of reading a novel. The latter is of course a less complex task.

For these three steps, evidence shows that both relational factors and feedback enhance learning outcomes, especially working alliance and motivation. Feedback over the course of the learning process enhances the effect of the teaching intervention. Personalized feedback systems fit into the unique profile of the student and monitor progress in his or her learning priorities. Conducting studies on creating a personalized feedback system adapted to the cultural diversity of the adolescent population in Europe could be an interesting task. Previous research shows that students' establishment of personal goals and the use of visually attractive mobile interfaces enhance the adherence of students/adolescents to learning processes. Moreover, a bottom-up definition of learning tools increases its acceptability among learners and teachers. Accordingly, a participatory approach, meaning working collaboratively with learners and teachers to co-design the features, is a recent development employed in order to strengthen the learning outcome.

Competencies

As attaining competence in a subject is a quite differentiated and complex task, a conceptual and methodological approach has to be developed. Several studies reached the consensus that the concept of personalized reasoning consists of intuitive and analytical components^[14-16]. Therefore, the methodological approach to teaching (*e.g.*, personalized reasoning) that can be investigated in research studies on mental processes consists of providing problem descriptions or patterns that can then be stored in "frames," "scenarios", "semantic networks/qualifiers", or in health professions, "illness scripts." Repeated presentation and training of real-life situations and cases is furthermore crucial for an efficient learning process^[16,17]. These considerations led to the implementation of interactive scenarios in many didactic consideration and teaching efforts^[16-19]. Advanced statistical techniques that enable us to discover patterns in data and make predictions on natural phenomena and human interactions with their environment may be used. Pattern recognition, consolidation of relevant phenotypes, and development of prediction and classification algorithms for developing decision rules can, for example, be refined.

Research strategies to investigate competence development can either use observational methods, questionnaires, and / or follow the development of item sets that can be condensed and studied further as factors^[14] and empirically validated.

Attitudes

Attitudes influence competence development. They provide insights into how biographical experience, motivation, and personality traits have changed in response to social changes. Who we are today is in part a result of our collective responses to social and cultural change and may have potentiated a decline or an increase in prosocial traits in students. The challenges of preparing students are better understood when viewed within the broader social context.

An attitude especially in health or pedagogic professions normally contains empathic, precise, ethically sound and scientifically grounded decision making and authentic care. Identification processes play an important role in reaching this ideal attitude ("Hidden curriculum")^[20] as do secondary socialization processes (*i.e.*

integration of social norms, values, training of most important roles, preparation of role-acquisition, and occupational role).

In this context, research might include process research, conceptual research, as well as questionnaire/observational methods with each of their own respective research paradigms.

For research in this context, drawing upon influences from psychotherapy research and social neuroscience is helpful in order to target and understand learning processes: For example, Sharpless *et al.*^[21] measured the program performance of universities and teaching institutes in higher education by calculating prediction models for the Examination for Professional Practice (EPPP) at the end of a university program. Pass rates and program performance of universities in the United States and Canada were higher when the total amount of internships and emphasis on practical aspects were high and very prominent in the curriculum. Overall, the EPPP showed numerous advantages and better results in case the higher students had scored in the PreGraduate Record Examination in total, or the higher the percentage of Cognitive Behavioural Training Elements - CBT orientation was. Interestingly, program performance correlated positively with higher percentages of ethnic minority students in the program.

In addition to environmental factors, precise biological factors and structures may be investigated in order to understand learning processes: The encoding of subjective value is directly related to emotional regulation as well as neuro-structurally related to the ventral prefrontal cortex^[22], and psychological mindedness is connected with metabolism in the right precuneus^[23]. Fear influences decision-making, especially in narcissistic states^[24], as links between affective and cognitive functioning may influence the sense of self-agency. These examples of results show the diverse factors that play a role in the complex puzzle of research on learning and training.

Identity, identification, and social reality

Attitudes are to a great extent influenced by identification processes that start very early in life. In addition, neuro/psycho-developmental aspects also have to be considered: It is well established that psychoanalysis provides knowledge that helps us understand the development of personality. Researchers have begun to emphasize more and more the role of affect regulation in personality, development, and individualization and identification processes. Affect regulation refers to cognitive and behavioral strategies people use to maximize pleasant emotions and minimize unpleasant ones. These strategies may be explicit (coping mechanisms) or implicit (defenses). It has been proposed that feelings are mechanisms for the selection and retention of behavioral and mental responses. To the extent that particular behaviors, coping strategies, or defensive strategies become associated with regulation of aversive affective states and maximization of pleasurable ones, they will be encoded as "solutions" to affective problems. From this viewpoint, affect regulation strategies are a form of procedural knowledge and are activated under specific circumstances, such as the presence of particular affects. Affect regulation strategies can be adaptive or maladaptive. Some regulation strategies are affect-specific, whereas others can be used to regulate multiple affects of similar valence. These procedures are often activated to resolve discrepancies between perceived and desired states of self, significant others, and external circumstances. Emotions and other sensory feeling states are evolved mechanisms for channeling behavior in directions that foster adaptation. The avoidance of unpleasant states and the pursuit of pleasant ones leads to goal-directed mental and behavioral processes, including defenses and compromise formations. Affects provide a flexible motivational mechanism in humans, as they become associated with representations of perceived, feared, wished-for, or otherwise valued states through the interaction of environmental events and highly specific, naturally selected biological proclivities. The investigation of affect and its regulation also refers to the detection of coping styles. Vollrath *et al.*^[25] showed that dispositional coping styles prospectively influence change in personality. Observing affect parameters should not be left alone, as affects are activated under specific circumstances, *i.e.* in object-relationship. The concept of object relations has played an increasingly important role in psychoanalytic theorizing, as well as in clinical psychoanalysis, psychotherapy and medicine^[26]. A short summary of a few pertinent issues will provide a context for describing what is of interest: Ogden^[27] traced the contributions of Freud, Abraham, Melanie Klein, Fairbairn, Winnicott, and Bion to the conceptualization of internal object relations. The original model of all internal objects is Freud's model of the normal development of the superego through the process of identification, as the ego assimilates aspects of the personality and functions of external objects. This newly established psychic agency acquires its own set of

motivations and actions, including object relatedness. Ogden^[27] also drew on Freud's extension of the role of splitting of the ego, beyond the formation of the superego, in the development of internal objects. For Ogden^[27], another core concept is Fairbairn's assertion that it is an aspect of the relationship with the object, rather than aspects of the object, that becomes internalized. In addition, Ogden^[27] incorporated into his thesis Bion's description of the potential for the defensive splitting of the mind into active suborganizations capable of engaging in specific forms of object relatedness. Ogden^[27]'s elaboration of these concepts indicates that splitting of the ego into new subdivisions is necessary for early interpersonal relationships to be internalized. Each sub-organization – being a component of the ego – has a dynamic capacity to semi-autonomously generate experience and leave its stamp on the quality of object relations. This psychoanalytically informed view of object relations stipulates that they are the product of intrapsychic sub-organizations of the ego (internal object representations) and not of external interpersonal relationships. However, the quality of object relations is manifested in the interpersonal situation^[28]. Despite the enduring quality of object relations, these intrapsychic structures are modifiable by experiences during healthy development. It is suggested that secure attachment is the basis of the acquisition of metacognitive or mentalizing capacity. Horner cited that the concepts of internalization and of object relations are fundamental to the developmental psychology of psychoanalysis, especially in terms of therapeutic technique. The investigation of object relation styles benefits our understanding of problems that people with identity disturbances and/or problems in their mentalizing capacity have. Mentalization and reflective functioning is essential for learning. Primary socialization is the precursor for secondary occupational socialization and therefore plays a distinct role in education^[29].

When the influence of secondary socialization on attitudes is targeted, we have to provide research data on integration of social norms and values, training of the most important roles, considerations of the preparation of role-acquisition, and definitions or possibilities for operationalization of the occupational role, which is not correlated with development or education, but more influenced by social reality (Figure 1).

Investigation of social reality can be described as a specific situation experienced by a person that leads to actions and interaction. The person experiences a situation on the basis of his/her ego-id-superego (*i.e.* with ego-functions, wishes, moral values, *etc.*). Within the person, as well as within the process of connection between two or more persons, bargaining between each other's ego, id, and superego structure takes place. Both conscious and unconscious bargaining processes need to be taken into account.

METHODOLOGY

To investigate complex phenomena, several different research paradigms must be taken into account in order to identify as many influencing factors as possible. Which methodologies might be considered?

Neuroscience – memory (place neurons), neuronal, molecular levels, and computer sciences (Neurocircuits) have to be integrated into observational process research (*e.g.*, affective-cognitive interface, identification processes, *etc.*), and conceptual research has to be added and repeatedly discussed on a meta-level, with inclusion of discussions of research paradigms. These discussions should inform ongoing projects in a hermeneutic circle. In the same way as clinical theories have been developed on the basis of clinical cases, observations, and continuous discussion among experts, the way forward is to ground these theories *via* empirical research work as scientific theory. Thus, an interdependence of constructivist and empirical research paradigms may be synergistically combined.

Basic sciences relevant to neurosciences

On a molecular level, as has been investigated by Eric Kandel, the marine snail *Aplysia californica* was an important animal model for studying the molecular mechanisms of learning because of the very few, but very large nerve cells he uncovered. The objective was to study the gill withdrawal reflex of the animal, as it had been shown that it can be attenuated (habituation), enhanced (sensitization) or durably reinforced (conditioning). The basis of such changes is the interaction of different molecules in the nerve cells and transmitters in the synaptic cleft. These and other similar investigations on a molecular level are conducted in the neurosciences, fostering scientific knowledge with respect to brain- or memory-function (*e.g.*, research on place-cells^[30]), resting state- or DMN investigations, and *e.g.* research concerning the neuronal anxiety

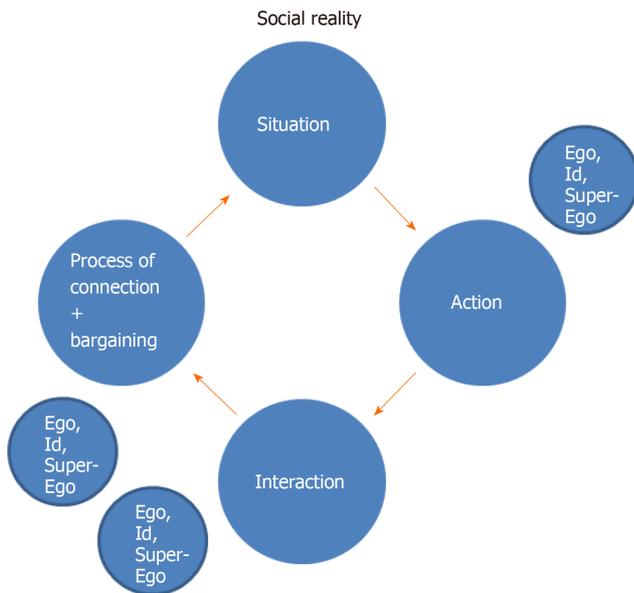


Figure 1 Social reality.

networks, all of which contribute to our understanding of learning processes.

Mathematics

As the measurement of change processes concern a number of actors (*e.g.*, therapists, clinicians, doctors, candidates, students) and their learning efforts, relevant variables, teaching aims, learning achievements, and factors must first be defined and operationalized, as these will determine a student's learning progress. For the purposes of evaluation of these learning and change processes, implementing a user-friendly applied model and software-package on different data (*i.e.*, on students' learning processes) will prove useful. In order to optimize the visualization software, regular monthly evaluations involving subtests have to be conducted. Afterwards, algorithms for model-building with the help of the computer algebra program MATLAB can be implemented and model parameters can be optimized; thus, the theory of the Hidden-Markov-Models is useful. Teaching experts almost universally agree that the definition of the requirements for user software and its implementation has to be discussed and specified in interprofessional teams. Hidden Markov models are stochastic signal models which consist of two random processes, wherein the first process is hidden and can only be accessed through the second. Initially, the first random process is defined as a Markov chain in order to widen it *via* the second into a Hidden Markov model. A discrete Markov chain consists of N states, whereby the system is always in one of these states. At discrete time points, the system states change. Over the course of these events, the probability that an actual state changes into a definite state is described with the aid of the state transition coefficient (see also^[31]). The most essential points are to work out descriptions of precise evidence-based physical (bio-psycho-social) parameters regarding the learning progress and to set up descriptions of mathematical logic, *i.e.*, data processing in a recurring interprofessional discussion process.

Both methodological approaches follow a natural sciences research paradigm and have to be integrated into a process research design. Some qualitative methods have to be added into a mixed-methods approach in order to justify the often diverse, subjective parameters of human beings.

Observational methods

In order to understand identification processes (relevant for research on attitudes), the affect-cognitive interface, or subliminal affect perceptions and their influence on learning in process research, observational methods have to be integrated. The idiographic design complements nomothetic research strategies, providing more differentiated answers to behavioral questions. For example, the meaning of nonverbal communication is widely known in psychotherapy research. So it is thus astonishing that nonverbal interaction has not yet been established in initial and further training of clinicians. Different patient and therapist variables need to be taken into account (*e.g.*,

via video analysis) in order to understand a number of complex aspects of the relationship. Within the scope of this research field, investigated micro-process-units are the clinicians' and patients' micro-expressions, as measured by the emotion facial action coding system^[32]. The ability to recognize facial expressions enables novel applications in human-computer interaction and other areas. Consequently, there has been active research in this field, with several recent works utilizing convolutional neural networks (CNNs) for feature extraction and inference. Being able to recognize facial expressions is key to nonverbal communication in human beings, and the production, perception, and interpretation of facial expressions has been widely studied^[33]. Advanced statistical techniques that enable us to discover patterns in data and make predictions about natural phenomena and human-environmental activity can be used. Pattern recognition, condensation of educationally relevant phenotypes, and development of prediction and classification algorithms for development of preventive decision-rules for states or problems like trainer-trainee feedback strategies may be developed.

Qualitative-quantifying research designs shed light into the ingredients relevant for change. Investigations that focused on trainers showed for instance the influence of a person/the therapist on treatment outcome when fruitful learning and change take place. Therapist effects explain up to 20% of the variance in outcomes^[34-37]. For research purposes, it is necessary to study the clinician/therapist dynamic in much more detail: We know that attitudes differ, or more precisely, that therapeutic attitudes differ between potential trainees (students)^[38], trainees in psychotherapy (propedeutics), and qualified psychotherapists. Attitudes are related, in that therapeutic attitudes relate to interpersonal problems and emotional reactions^[39]. Therapeutic attitudes also change over the course of additional training^[40]. Such research approaches of qualitative, interview-driven, quantifying designs advance operationalization of different relevant variables and parameters. Recording and transcription is another approach to be mentioned^[41].

Another finding was presented *via* experimental case-series design^[14], pointing out two different modes of thinking. Considering factors relevant for clinical reasoning, clinical decision-making, and authentic clinical care, factor analysis approaches showed three relevant factors and aspects: (1) Conscious analytic processing consisting of application of rules, conscious processing, reflecting upon reasons for procedure, meta-analytic information processing, and search for alternative; (2) Positive, holistic intuition consisting of variables like complexity, holistic processing, global rating, and clinician's emotional arousal; and (3) Automatization. Conscious-analytic processing and automatization varies with the level of training and the years of clinical experience.

In addition to these mixed-methods designs, conceptual considerations may be added.

Conceptual research

Transformative education^[42] based on disruption, action, reflection is one concept for learning – a mostly performative one. Taking unconscious/subliminal perception, fast and slow thinking^[43] processes, and implicit aspects into account, learning concepts could be widened – either *via* empirical conceptual research^[44] or *via* a theoretical, more rational epistemic approach.

METADISCOURSE

Conceptual research can be added and repeatedly discussed on a meta-level, also including discussion of research paradigms. This discussion gives feedback to ongoing projects according to a hermeneutic circle. New theoretical considerations could be implemented and investigated in a timely fashion, so that improvements can be adopted and pursued, and hindering factors can be avoided. Digitization, therefore, opens up new opportunities and avenues.

Designs

The main concern is how to combine empirical data with constructivist objectives, which can be solved within a combination of both qualitative and quantitative research methods. Nevertheless, when it comes to training of aspects such as authentic care, decision making, training in history taking, or training of other types negotiations, we have to take into account intuitive factors^[14], and/or in a broader sense, the social brain and mind. It consists of perceptions, *i.e.* conscious and

subliminal ones, attachment, commitment, refusal, mirror neurons, or mentalization. Findings show that perception, attachment, rejection, and mentalization network are perturbed by direct and indirect social stress. Therefore, the learning and teaching environment should be supported by didactically sound and affect-involving ingredients^[45]. One possibility to affectively involve students is the training of communication skills^[46] and discussion of cases in a structured and secure atmosphere. When social behavior is disrupted, a dysfunction in social perception, attachment, and rejection may be discerned. Thus, an adequate research design for learning has to take affect research into account. Case-based teaching can be assessed and studied along guidelines for case-studies^[47], and simulation and virtual-reality paradigms can be used to contribute to environmental validity.

Affect research: Theory and practical application

Based on the question of what empathy^[26] and especially what affects are, the relevant metapsychological formulations in S. Freud's work are examined within the framework of recent developments in psychoanalysis and neurosciences. The theoretical structure of a psychoanalytic affect theory relates, among other things, to the results of emotion research, endocrinology, and neurophysiology on the one hand, and to cognitive psychological, behavioral, and linguistic studies on the other^[48].

Recent research results from the neurosciences indicate that affects and their sequence of actions are clearly anchored in neurophysiology or require clearly, anatomically identified neuronal circuits. The facial expressions linked to affective expressions, gestures, posture, voice, as well as visceral patterns are part of subcortically integrated motor reaction patterns. Facial muscle movements and neuron firing do not reveal anything about the underlying intrapsychic dimension, which is our main interest. Affects are a central determinant of inner and outer reality.

Solms^[49] shows that the question of affects forces one to recognize the inner connection between the soul and the somatic and to bring this state of affairs into line with the theoretical designs of psychoanalysis. This leads to the conclusion that affect is a primary sense modality. While sensory modalities such as seeing or hearing represent aspects of the outer, objective world, affect is that primary sense modality in which the inner, subjective world is perceived, which in principle is unconscious. The scientific task is not only to describe and classify the superficial qualities of the inner perception, but also to gain an understanding of the "real facts" that underlie the sensory phenomena of the affect according to the psychoanalytic objective (see also^[52]).

Historically, Freud^[50] conceptualized affects in the context of his motivation theory, namely the drive theory, and defined the affects in a specific relation to the drives. In Freud's earliest drafts of affect theory, which are primarily to be read as fear-theoretical writings, an event that takes place in external reality triggers an affective reaction that becomes meaningful due to the connection with a certain idea.

In modern affect theory designs, a connection between instinctual and affect events is assumed, but other sources of motivation appear earlier in addition to the instincts. Modern psychoanalytical affect-theoretical designs can be divided into the subject areas "affects and drives", "affects and ego development" and "affects and object relationships". According to Krause *et al.*^[51], one has to differentiate between Freud's drive theory and his biological foundation of the drive concept and psychological drive theory. Although it turned out that Freud's attempt to find a biological foundation for the concept of instinct using ideas from the stimulus physiology of the time was insufficient, it should be noted that the derivation of the concept of instinct from biology was considered necessary. In the psychological part of instinct theory, Freud differentiated between instinctual source, instinctual goal, and instinctual object, and thus tried to grasp "instincts" by their goals and not by their causes. Starting from an ethological understanding, many instinctual processes are social processes in which the characteristics of the object have the same power to trigger behavior as internal sources of stimulus. Freud's social component only comes into play through the so-called drive object. Bowlby^[52] revised the classical instinct theory, taking into account the approaches of ethological instinct theory in their application to attachment motivation.

Following the discussion of Freudian concepts of affect, affects were considered from the aspect of the instinctual event, the object relationships, as well as in connection with ego functions. In their affect-theoretical discussion, contemporary psychoanalytic theories mostly address the connection between affect and ego functions as well as affects and object relationships - including the object relationship theories of M. Klein and D. Winnicott. Knapp's exemplary compilation of affect-theoretical designs from the fields of psychology, neuropsychology and psychoanalysis offers optimal guidance and understanding^[48,53] for the basic building

blocks of psychic life and, above all, poses neurophysiological and psychosomatic questions.

One possible research design

Application of methods to better measure and interpret non-verbal communication in personalized interactions may aid in the search for modulators of efficacy in dyadic encounters. One hypothesis could be formulated: Affective micro-expressions at the encounter's beginning predict working alliance. The objective is to develop a method of examining facial affects in therapeutic settings and interpreting the underlying emotions they represent, with a perspective on future exploitation in the form of computer-based treatment/monitoring tools. Methodologically, personalized encounters or treatment sessions (aiming at change) are videotaped, and verbal content is evaluated with computer assistance from ATLAS.ti. Visual content is screened for facial action units/micro-expressions using the Emotional Facial Action Coding System and reevaluated utilizing CNNs for feature extraction and inference. Working Alliance Inventory scores are compiled to assess their impact on the quality of the therapeutic relationship. Reliability of facial action unit coding is ensured by a training course and an independently-evaluated, standardized test. Interrater reliability can be calculated. Recognizing such expressions under naturalistic conditions is likely, however, more challenging. In order to highlight the methodological differences between these works, we have to break down each method into the three components: (1) Preprocessing; (2) CNN architecture; and (3) CNN training and inference. Amongst other things, a major finding could be that confrontations are linked to the display of specific affects and micro-expressions in both therapist and patient alike. Interestingly, it may be that the display of some micro-expressions also correlates with a higher WAI score. Results could be a consequence of the complexity of affects and the interplay of primary/subliminal and secondary emotions. Finally, we may be able to describe the circumstances of the routine evaluation and feedback elements to the interviewer *via* a computer-based feedback slope if we can develop a such a system for regular evaluation purposes.

Looking ahead, as many recent activities concentrate on training issues, as well as change- and learning-processes, further collaboration between neuroscientific (subliminal perception) and imaging techniques (associative learning, DMN) is a logical way to go. As educational sciences are based on (social) neuroscientific findings^[12], such an approach could shed light on relevant interaction processes. Indeed, feedback-studies or randomized controlled trials on supervision processes could be conducted. Another area of particular interest might be micro-expressions, focusing on subliminal/unconscious interaction. Drawing upon lessons learned from conditions that impair social cognition (Digeorge 22q11DS-syndrome/Moderator-MA for treatment efficacy), this may help further training (Mentalisation Based Treatment + training) of educators /mentors in simulation scenarios (compare BeSiC/Bern, tEACH).

While an evidence-based approach to the practice of medicine has become accepted as an absolute requirement, (medical) educators have been slow to apply a similar approach to the educational process. Yet there exists a wealth of evidence-based learning strategies which have been studied in seminar settings and reported in social neuroscience and cognitive science literature. As the knowledge base grows exponentially, with the result that students need to learn ever-increasing amounts, the very best strategies and the tools necessary to apply those strategies should be provided. These will be essential to facilitating this essential transformational process and to describing some of the most effective learning strategies and their application to teaching processes. The approach leading to evidence-based teaching, dependent on evidence-based findings that emerged from carefully performed basic science studies and which were subsequently validated in clinical trials, now forms the basis of nearly all (clinical) decision-making today.

A scientific approach to studying which methods or strategies were most effective in the learning process has been validated in real-life classroom studies leading to the following key findings.

As the doubling rate for knowledge production for 2020 has been estimated to be just 74 d and the effectiveness of *e.g.*, medical treatments vastly improve when treatments were directed by evidence-based science, a similar approach has to be implemented if our students are to be adequately prepared to be doctors in the 21st century. In order to make the learning process as efficient as possible, we have to provide: (1) Spaced learning: Spaced repetition algorithms spread learning opportunities over time to improve knowledge retention. Students should have access to delivery-optimized recall questions, while the learning format itself spreads out the

topics being studied so that there is space between the study of the same medical concepts; (2) Interleaving: Knowledge should be broken down into 'easily digestible' sessions. This enables students to learn more effectively by easily switching between different topics. Doing this helps students learn the similarities and differences between different medical concepts, giving them a holistic and interconnected knowledge base; (3) Didactics videos: Dual coding, which combines verbal and visual representations of the same information, should be utilized as students learn best when they have multiple representations of the same idea. Learning science also shows that shorter length representations (3-9 min) are important for increasing knowledge retention; and (4) Active retrieval: Quiz questions at the end of each learning unit should ensure learner engagement utilizing frequent low-stakes or no-stakes assessments.

Furthermore, readiness assessments should be implemented, as well as briefings and debriefings of active learning formats supported by assignments with detailed drill-down analytics that bring data-driven learning to the forefront for every instructor. An example was shown at: <https://my.ltb.io/www/#/> or <https://moodle.meduniwien.ac.at/course/view.php?id=682>. Data-driven solutions are the key to improving the educational process.

CONCLUSION

Neuroscience^[54] defined the non-conscious and allowed some connections between biology and behavior to be made. Mathematics and computer science have put some effort into simulating the mind^[55]. Considering the speed, breadth, and depth of technical/technological advances today, it is necessary to develop specialized domain knowledge, and therefore interdisciplinary working groups need to develop glossaries. The main domains could then be tested and discussed again in a hermeneutic circle to influence and see the impact on the learning process per se. Research into the subjectivity of human beings (students, trainees) may be empirical, qualitative, or inductive, but should ideally be re-evaluated by the subject in an idiographic manner.

To give an example illustrating the current dilemma as well as the need for at least two perspectives, consider that in psychoanalytic literature, countertransference is usually described in a self-report format by the therapist. For example, the most recent psychometrically sound self-report measure, the Countertransference Questionnaire^[56,57] asks the therapist to report his or her feeling/reaction towards the patient by indicating whether sentences such as "I feel guilty about my feelings toward him/her." (Item 24) are true. However, even in retrospect, these reports fall prey to the unavoidable "blind spots" of the therapist. Therefore, psychotherapy process research has searched for other, more rigorous ways to capture countertransference, which requires gauging the ongoing therapeutic process in a multimodal manner, encompassing self-report and observer-rated measurement. The most frequently applied observer-rated instruments are the Countertransference Factors Inventory (CFI^[58]) and the Inventory of Countertransference Behavior (ICB^[59]). The ICB can be used by supervisors to assess therapists' positive and negative countertransference behaviour in a specific session, whereas the CFI has a broader focus on therapists' competencies that may be important to countertransference management. The dilemma of both perspectives, self-report and observer-rated, is that the former is vulnerable to the therapist's "blind spots", while the latter is confined to the therapist's observable verbal behaviour, or, as Hayes has cogently expressed: "therapists' self-reports are limited by what they are willing and able to reveal, and raters' observations are restricted to overt displays of countertransference"^[60]. Ideally, one could triangulate further *via* video-based investigations into unconscious/subliminal perceptions.

Personalized feedback systems promote change, and the more subjective perception and experience is assessed and reconsidered, the better significant change can take place. Differentiated steps may be undertaken to promote motivation, provide more security in disruptive times, and make change possible. Triangulated research designs, domain knowledge, and knowledge on data reduction might be considered in conjunction with idiographic assessment of subjective values, subliminal affect perceptions and attitudes, and values and beliefs.

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