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Towards a Deeper Modeling of Emotions: The DEEP Method and its Application on Shame

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***Abstract*—Understanding emotions is key to Affective Computing. Emotion recognition focuses on the communicative component of emotions encoded in social signals. This view alone is insufficient for deeper understanding and computational representation of the internal, subjectively experienced component of emotions. This paper presents the DEEP method as a starting point for a deeper computational modeling of internal emotions. The method includes how to query individual internal emotional experiences, and it shows an approach to represent such information computationally. It combines social signals, verbalized introspection information, context information, and theory-driven knowledge. We apply the DEEP method exemplary on the emotion shame and present a schematic dynamic Bayesian network for modeling it.**

***Index Terms*—Emotion Modeling, Methods, Empirical Study**

I. INTRODUCTION

Technological support for social and human affairs requires theories about the human psyche and societal structures. Within that context, the concept of emotion and the understanding of individuals' emotions seem very relevant. It comes with the hope and intention that through recognizing emotions, meaningful information about how an individual truly assesses or experiences a situation can be gathered [1]. This information then could be exploited for a user model adapting to users' actual needs. The crux is that emotions – seen as individual internal experiences – cannot be recognized, at least with current approaches [2], [3]. Emotions have communicative components that are displayed in social signals and physiological parameters, but also internal components that reflect individual internal experiences [2], [4].

Research and applications of Affective Computing rely on understanding the emotions of the user. Thus, many attempts exist to infer user emotions exploiting different sources of data like speech, facial expressions, body gestures, and movement – unimodal as well as multimodal [1]. This is still challenging, as emotions are a complex, hypothetical construct accompanied by changes in various components, including physiological reactions (e.g., heart rate) and behavioral components (e.g., facial expressions, gestures, and voice parameters) [2], [3].

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Despite many efforts, a reliable assignment of observable reaction patterns to emotions, such as shame, fear, or surprise, remains unsolved [2], [5]. This is not surprising knowing that emotions also have less directly accessible components, namely the subjective, internal experiences that might not be communicated [2], [4]. Furthermore, in one particular situation, more than one emotion can arise [6], and emotion regulation allows masking internal emotional experiences [7].

However, for Affective Computing, it is crucial not only to understand and make assumptions based on the display of emotions but also to consider and represent their individual experience. Therefore, this paper presents the novel DEEP method with the purpose of gaining a deeper understanding of emotions that can be used for computationally understanding and modeling emotions. We show how we apply it to the emotion shame and how it could be realized with a dynamic Bayesian network approach.

II. BACKGROUND AND RELATED WORK

A. Functions of Emotions

To understand and model human emotions, especially in interactive social situations, understanding the functions of emotions is crucial. With their *intrapersonal functions*, emotions help us to operate quickly. As a rapid information-processing system, they enable acting with minimal thinking. They prepare the body for immediate action, for example, in dangerous situations, and are connected to perception, attention, inference, learning, goal choice, motivational priorities, physiological reactions, motor behaviors, and behavioral decision making [8]. The *interpersonal functions* of emotions refer to the role they play between two or more individuals. Humans express emotions verbally and nonverbally, which can be recognized by others [9]. With their signal value, they influence interactions, for example, by evoking responses in interaction partners [10]. Emotions also provide incentives for desired social behavior and therefore regulate social interactions [11]. The *socio-cultural functions* of emotions refer to the role they play in maintaining social order within a society. The cultural background defines which emotions are valued more [12], how emotions are displayed and regulated [10]. Humans

manage, modify and express emotions through cultural display rules. These rules, usually learned in early childhood, define the appropriateness of emotional displays in certain social situations [13]. As a result, especially negative emotions are often masked and not expressed openly [5].

B. Model of Emotions and Emotion Regulation

We follow a model of emotions that differentiates between internal (structural and situational) and external (communicative) components [4]. *Structural components of emotions* represent information about the appraisal of one's attributes and actions. They are related to the self-image and provide information about its state. *Situational components of emotions* represent information linked to a topic or situation that has been experienced. If a situation addresses social skills or relations, the emotions shame or pride might be linked. *Communicative components of emotions* represent the information that is communicated externally and therefore verbally and non-verbally encoded in *sequences of social signals*, like vocal or facial expressions [14]. It also represents the information that is communicated to the person itself, like physiological reactions. Due to several processes, internal and external components might not match [2], [4]. Influencing variables of the display of emotions are, for example, display rules [13] or emotion regulation processes [7].

Because most, if not all, emotions are regulated, understanding them is highly difficult. Emotion regulation refers to how humans try to influence which internal emotions they experience [7]. This process can be conscious or unconscious. Emotion regulation can mean the regulation *by* emotions, referring to how emotions regulate something else, such as blood pressure, or it can mean the regulation *of* emotions, referring to how emotions themselves are regulated. People regulate emotions to avoid experiential and/or behavioral aspects of (negative) emotions such as anger, sadness, and shame. Gross specifies five types of regulation strategies: situation selection (choosing situations that are promising to experience wanted emotions or avoiding unpleasant situations), situational modification (modifying a given situation), attentional deployment (redirecting attention without changing a situation), cognitive change (changing one's appraisal of a situation in a way that alters the situation's emotional significance) and response modulation (influencing physiological, experiential, or behavioral responses). One form of response modulation is suppressing an emotional expression, like the effort to hide shame in an embarrassing situation [7].

C. Emotion Recognition and Emotion Modeling

There are many attempts to recognize human emotions in the field of Affective Computing [15]–[17], as well as to model them in computational emotion models (see [18], [19] for an overview). Recently, interdisciplinary approaches are aiming to combine both [20], [21].

The MARSSI model [21] relates appraisal rules and emotion regulation rules with social signal interpretation. It differentiates three functional dimensions of emotions: communicative, situative, and structural emotions. This notation allows a more accurate description of emotions. Also, it allows defining multiple possible, plausible relations between communicative emotions (cf. emotional expressions) and sequences of social signals to individual appraisal and regulation strategies. Elicited structural emotions can trigger the latter. However, this approach does not go beyond representing internal emotions as a label. Human internal emotions are always connected to subjective experiences and individual contexts that both can be computationally modeled (Sec. III, VII).

For decades, researchers assumed that emotions have distinct patterns, like fingerprints, that are objectively observable (e.g., in facial expressions or brain activity). However, it seems that this is not the case. There is no one-to-one mapping between a specific set of facial muscle actions or vocal cues and any and every experience of emotion [2]. Moreover, the different measurements of emotions (physiological, behavioral, and experiential) are only feebly inter-correlated [3]. This might be why identifying objective, external means to measure the subjective, internal experience of emotions is complicated [2]. Therefore, other methods to acquire this information about emotions need to be explored.

One evident approach is to ask people about their subjective experience in self-reports [22] in which they describe their internal experience [23], [24]. While questionnaires are suited for collecting quantitative data, for qualitative data, like internal experience, interviews and especially semi-structured interviews might be a more appropriate method [25].

This work aims to develop a method to explore not only communicative components of emotions that are observable but also structural components of emotions that are internal.

III. Development of the Deep Method

All emotion recognition and emotion modeling methods can merely be seen as an approximation to individual internal experiences. We propose the DEEP method, a multi-method approach to optimize this approximation combining four sources of information about one specific situation:

1) **Social signals**: Observation of communicated emotions that are encoded in social signals in the specific situation.
2) **Verbalized introspection information**: Self-reports that reflect a person's subjective experience gathered in semi-structured interviews after the specific situation with the aid of video material of the experienced situation.
3) **Context**: Social situation, display rules, roles of interaction partners in the specific situation, and information about the user like preferably applied regulation strategies, intention, personality, and others.
4) **Theory-driven knowledge**: Information about possible regulation strategies that can appear in social situations.

For a computational representation of this four sources of information, we anticipate a cognitive-oriented modeling with a dynamic Bayesian network (DBN) (Sec. VII).

A. Social Signals

Compared to approaches of emotion recognition, the DEEP method includes analyzing social signals communicated in a specific situation, too. For real-time analysis, we use the Social Signal Interpretation framework (SSI) [26]. SSI especially allows synchronized processing of multiple sensor inputs in real-time. This includes the extraction of relevant features at runtime and the appliance of machine learning models, such as deep neural networks or support vector machines (SVM) for predicting single cues, such as changes in gaze or head direction, facial expressions, gestures, and postures.

B. Verbalized Introspection Information: Self-Report

The core of the DEEP method is the information from participants' self-reports about their internal experience. This information reflects the indirect introspection of the participant with the experience of interest lying in the past. It is recalled as a memory which is then observed and verbally described. [27]. Semi-structured interviews obtain these self-reports suitably. They allow researchers to gain a deep understanding while following a guideline that ensures coverage of all important topics [28], and the comparability of results [29]. This interview form is versatile and flexible: It gives space for interviewees' individual reports and allows an exploration of the topic that may bring up yet unconsidered aspects. Moreover, it enables reciprocity between interviewer and interviewee [28]. For the use case of gaining information about internal experiences, semi-structured interviews are especially suited, as the collected data is rather personal, and retrieving it requires a careful and complex inquiry approach [30].

To enhance the quality of verbalized introspection information from the semi-structured interviews, we propose to apply several techniques:

Supporting memory. The introspection follows immediately after the situation that is studied. To facilitate the process of remembering, experimenter and participant watch together a video of the studied situation [28].

Creating comfort includes a positive atmosphere and the creation of a trustworthy relationship. The interviewer uses well-established nonverbal immediacy behaviors to show interest and engagement by orienting the body toward the interviewee, reducing interpersonal distance, smiling, showing open postures, and making eye contact [31]. On the verbal level, the interviewer self-discloses [32] and elicits an in-group feeling [33], e.g., by confirming that it would also be difficult for him or her to talk about internal experiences. The set-up of the interview room ensures a feeling of privacy without disturbances. Interviewer and interviewee are seated at a 90° angle, optimal for interaction [34].

Encouraging to speak openly is realized by showing interest and appreciation of what is said, e.g., with verbal and nonverbal backchanneling signals [35]. Psychotherapeutic questioning techniques encourage the interviewee to speak openly about every thought and feeling that comes to their mind [36]. Also, challenging questions are mixed with less stressful ones.

Reassuring information. To ensure a correct understanding of the interviewee's explanations, the interviewer paraphrases and summarizes the interviewee's answers after difficult questions. This facilitates the required interpretation of introspection results, as they are not self-explanatory [27].

Selecting participants based on a priori formulated criteria is a valid method to improve qualitative research results [28]. The extent to which people can access their mental processes and states (e.g., emotions) varies inter-individually [22], [37]. Hence, we pre-selected participants regarding*psychological mindedness* [38] that has four factors: 1) the skill to discern connections between meanings and causes of behaviors, which requires both intact cognition, intuition, and empathy; 2) the goal of understanding the meaning of behaviors, which entails an interest in the way minds work; 3) self-directed psychological thinking; and 4) the "ability to engage in psychological thinking". However, selecting participants can affect the generalizability of the results (cf. Sec. VIII).

C. Context

Emotions are generally elicited by (external or internal) stimulus events [39]. Information about this stimulus event and its context can improve modeling of an individual's internal experience. This context information may include knowledge about the interaction partners' cultures, as they highly influence, e.g., how emotions are communicated [13]. Moreover, it may include knowledge about the social situation and the roles of the interaction partners [40]. Context information can include knowledge about interaction partners' personal factors, such as preferred regulation strategies, psychological mindedness, mental load, intention, personality, as these can influence the internal experience in a specific situation.

D. Theory-driven knowledge

To understand, follow, and computationally represent individual situational experiences, a deeper knowledge of emotion and connected regulation processes is mandatory (Sec. II-B).

IV. Application of the Deep Method

The starting point for applying the DEEP method was a previous study examining the emotion shame during the high-stakes situation of a job interview with a virtual interviewer [41]. Results indicated that participants experienced shame in the shame-eliciting interview independent of the elicitor (human vs. virtual agent). They were based on observations of theoretically founded signals of shame and shame regulation. Self-reported questionnaire data regarding perceived discomfort in the shame-eliciting situation confirmed the finding.

However, as described before, analyzing the communicative component of emotions and self-assessment of emotions via questionnaires has several restrictions. Those especially apply for the emotion shame, as it leads to a highly unpleasant state that is difficult to cope with. Shame is rarely experienced consciously [4], [42]. It is a social emotion and emerges particularly when individuals value the interaction partner's opinion (of them). The self fears rejection by the other in shameful

situations [43]. Such a situation poses a threat to relationships and the self-concept by disclosing unfavorable information about the self. Thus, most often, it is immediately regulated unconsciously and not displayed openly [4], [5], [7]. While they can manifest in observable behavior, shame experiences can remain solely internal, thus unobservable. Therefore, the observational and questionnaire data collected in the previous study may have not fully captured the very individual internal experience of shame. Also, shame is more challenging to talk about than other emotions [44]. Shame emerges when one notes failing to meet specific social standards. It is not elicited by a situation itself, but by an evaluation of that situation [42]. To conclude, the recognition of the highly complex emotion shame with existing methods might be impossible — thus requires a more careful and involved multi-method approach like the proposed DEEP method.

When analyzing shame, regulation processes have to be taken into account. Nathanson describes four shame regulation strategies: 1) Withdrawal can manifest in avoiding eye contact and silence. The wish to hide or leave is characteristic of this strategy; 2) Attack Self is characterized by blaming oneself and addressing what others might accuse us of, thus regaining control. It can manifest in expressions of disgust or indignation toward oneself; 3) Avoidance is the effort to deceive oneself and others by pretending nothing has happened and directing the attention elsewhere; 4) Attack Other means answering a shame-triggering statement with a counterattack. Anger and disgust might be expressed towards the other. Here, termination of the relationship is accepted [5].

V. STUDY METHODS

The present study's goal was to apply the DEEP method to a tested scenario. We oriented on our previous study examining the emotion shame [41]. Beforehand, we obtained approval from the project's ethical review board. As planned, data was collected in November and December 2019.

A. Screening and Participant Selection

In the study, participants were asked to elaborate on their internal experiences and possible explanations for emotions and cognition (see IIID. Therefore, we screened 35 psychology master students (28 female, $M_{age} = 23.97$ years, $SD_{age} = 2.20$ years) with the *Psychological Mindedness Scale* [45]. It consists of 34 items on four factors: interactive solution style, openness for change, access to one's feelings, willingness to try to understand oneself and others. Items were answered on a scale from 1 (*strongly disagree*) to 6 (*strongly agree*). Cronbach's Alpha ranged from .53 to .83. From the screened students, 27 reached a mean value beyond 4.5 (i.e., they either overall *agree* or *strongly agree* to be psychologically minded).

B. Participants

Due to the qualitative character of the study and the very detailed data analysis, we planned a sample size of n = 10. From the 27 invited participants, the first 10 (7 female) that registered participated in the study. Participants were aged between 22 and 32 years ($M = 24$, $SD = 3.06$) and had high values in the *Psychological Mindedness Scale* ($M = 4.87$, $SD = 0.97$). They were rewarded with 20€.

C. Procedure

Three days before the experiment, participants received the pre-questionnaire via email. On the interview day, participants were welcomed in the experimenter's room and informed about the procedure. After that, they filled in the shame experience questionnaire. Next, they were introduced to the job interview role-play for which they should imagine they applied for a student assistant position at their favorite university chair. They were told that a female virtual interviewer would conduct the interviews. Then, the experimenter guided them to the interviewer's office, which they entered alone. In the office, the virtual interviewer welcomed and asked them to sit down, then started the structured job interview conducted by the interactive social agent Susanne [41]. The interview included two shame eliciting situations: ("A brief question before we start. Where did you get this outfit? Somehow it doesn't really fit you." and "All the other applicants have already said what you said. You haven't exactly stood out."). During the job interview, the agent's turn-taking behavior was realized using a Wizard-of-Oz approach, with the wizard controlling when the agent starts talking. The experimental and technical set-up was like in [41]. After the second shame-eliciting situation, the experimenter interrupted the interview, confirmed that it was planned like this, and handed them the shame experience questionnaire. The experimenter guided the participants back to the experimenter's room and revealed that the study's purpose was not the job interview itself but how they cope with the shame-eliciting situations. The post-interview followed. Afterward, participants answered the post interview assessment questionnaire. Finally, they were debriefed and paid. The whole procedure took ≈60 minutes.

D. Measurements

Demographics included age and gender and were covered in the pre-questionnaire.

Shame regulation strategies were measured with the Compass of Shame Scale [46]. It assesses the use of the four shame-coping strategies described by Nathanson [5]: Withdrawal (WD), Attack Self (AS), Avoidance (AV), and Attack Other (AO). The questionnaire uses a description of a situation, for example, "When other people point out my faults" and reactions covering the four possible strategies: "I want to run away." (WD); "I feel like I can't do anything right." (AS); "I refuse to acknowledge those faults." (AV); "I point out their faults." (AO). In total 12 situations are described which results in 48 items. Each item was answered on a 5-point scale from 0 (*never*) to 4 (*almost always*). The questionnaire was translated into German and presented in the pre-questionnaire. Cronbach's Alpha ranged between .62 and .89.

Shame experience was measured before and after the job interview with six shame items from referring scales of the German version of the Differential Emotion Scale (DES) [47]

and the Positive And Negative Affect Schedule (PANAS) [48]. Two own items ("indignant" and "abashed") were added. To avoid priming, especially before the tasks, we included 11 shame-unrelated items of the DES as well as the PANAS. Items were answered on a scale ranging from 1 (*not at all*) to 5 (*very strong*). Due to increased Cronbach's Alpha, for the analysis, the item "shy" from the DES was removed. The resulting Cronbach's Alphas were .76 for the pre-test and .89 for the post-test.

Social signals in the shame eliciting-situations were observed and used for evaluating the occurance of shame and shame regulation as in [41].

The *post interview* took place after the two shame eliciting situations. It followed the guidelines described in III-B. Participants were asked to talk openly about everything they think and feel, even if it seemed difficult. It was pointed out that the goal is to find out the very personal internal experience of the participant and that there is no right or wrong. Openness was also encouraged by emphasizing the research gains their reports bring. The interviewer asked if participants would like to see themselves during the two shame-eliciting situations on video. Consent was given by all, except one, participant. After the first situation the interviewer paused the video and asked the first broad question "What are your thoughts about this situation at the moment?". Further questions narrowed down the topic to internal experience, regulation strategies, bodily reactions, explanations for the emotions, cognition and behaviour, as well as connection between internal experience and social signals (e.g., smiling). Questions were formulated in a non-suggestive way so that participant's answers were genuine. The interview is designed that participants have the opportunity to mention feelings of shame on their own. If throughout the interview this did not happen, the interviewer explained that the job interview was supposed to elicit shame and provided a definition of shame. Then, participants were asked again about their internal experience in the situation. The procedure was repeated for the second situation.

Assessment of the post interview was measured with four self-constructed items on a scale from 1 (*strong disagreement*) to 5 (*strong agreement*). Items were "In the interview I openly said what I felt.", "It was difficult for me to talk about the experienced situation in the interview.", "The interview was agreeable.", "I was reluctant to talk about my feelings." (Cronbach's Alpha .93).

E. Post Interview Interpretation

The post-interviews were transcribed and jointly analyzed by three trained raters – one of them an experienced psychotherapist – regarding six variables: *1. Reaction in shameful situation*. We analyzed if a regulated shame vs. an open shame reaction is shown in the job interview and elaborated in the post interview. *2. Relationship*. As some shame regulation strategies are connected to a termination of the relationship with the other, we analyzed whether participants wish to maintain or terminate the relationship with the job interviewer. *3. Consciousness of shame in situation*. As shame is strongly unpleasant and poses a threat to the self-concept, it is often regulated and not consciously experienced. We analyzed whether participants were aware of shame in the shame-eliciting situation or not. *4. Mention of shame*. We analyzed whether participants mention on their own initiative that they felt shame. *5. Regulation strategies*. Based on the answers in the post interview, raters assessed which shame regulation strategies were applied. *6. Shame induction*. Based on elaborated shame regulation strategies and social signals in the shame-eliciting situation, raters assessed whether or not shame was elicited, also if shame was mentioned.

VI. Study Results

In total, we video-recorded 20 shame-eliciting situations and audio-recorded 10 post-interviews.

A. Questionnaire Data

Shame experience. Participants reported significantly higher experienced shame after the job interview ($M = 1.90$, $SD = 0.80$) than before ($M = 1.18$, $SD = 0.24$), analyzed with a t-test for dependent measures ($t(9) = -2.66$, $p = .013$, $d = 0.85$.

Shame regulation strategies. In the pre-questionnaire, participants self-reported their regulation strategies. In decreasing order, the regulation strategies were: Attack Self ($M = 2.18$, $SD = 0.66$); Withdrawal ($M = 1.96$, $SD = 0.49$); Avoidance ($M = 1.51$, $SD = 0.44$); Attack Other ($M = 1.25$, $SD = 0.36$).

Post Interview Assessment. Participants assessed their openness in the post interview and its agreeableness as high ($M = 4.30$, $SD = 0.87$).

B. Analyses of the Post Interview

The analysis of the situations and their respective elaborations during the post interview regarding *1. Reaction in shameful situation*, *2. Relationship*, *3. Consciousness of shame in situation*, *4. Mention of shame*, and *5. Regulation strategies* are enriched with quotes of participants (Tab. 1). In addition to Nathanson's regulation strategies [5], 15 other strategies were found, which are not elaborated in the present paper. Regarding *6. Shame induction*, raters assessed that in 18 situations, shame was induced. Shame induction was rated if the shame experience was mentioned explicitly or a shame regulation strategy was applied. The two remaining cases are unclear due to discrepancies between observed signals and information from the post interview.

C. Example Analysis

One study's goal was to examine the internal experience of participants throughout a shameful situation. Therefore, in a step-by-step process, we analyzed the video of the participant in the shame-eliciting situation as well as the verbalization of internal experience from the the post interview, connecting both data sources. We present the analysis of the first shame-eliciting situation using the DEEP method (Fig. 1).

Table I: Descriptive data and supporting quotes of participants.

Variable	Value	Frequency	Quote post interview
Shame reaction	not open	19	see variable **Regulation strategy**
	open	1	I showed shame rather open. Otherwise, I would not have apologized (#1)
Relationship	maintain	14	I still had the goal of getting the job (#3); I wanted to impress her (#4); Repair the image (#9)
	terminate	2	With people I don't like, I just don't care about them at all (#8); I would have liked to leave (#10)
	unclear	4	Go away (#4) vs. To still somehow impress her (#4)
Consciousness of shame	yes	13	I felt a bit inferior (#4); I think it was that sense of shame at that moment. This *Oh, I don't fit in here. What did I do wrong?* (#6); I felt this unpleasant feeling consciously in the situation (#10)
	no	7	In the situation, I was angry. But now I realize that I tried to cover shame (#4)
Mention of shame	yes	15	I felt ashamed; It was unpleasant (#1); I felt unwell (#3); I felt personally attacked; I felt inferior (#4); This situation elicited more shame and discomfort (#5); I felt hurt (#10)
	no	5	Shame rather didn't get to me (#3)
Regulation strategy	Withdrawal	8	I avoided her gaze (#4, #5 #10); I had to let the situation pass by; I had to introspect and think about it (#9); I was overwhelmed, thus silent (#10)
	AttackSelf	1	I acknowledged she was right and I tried to improve my answer (#2)
	Avoidance	10	I diverted attention and did not really react on it (#2); I felt somehow offended and covered it up with the smile (#4); I thought it's funny (#7)
	AttackOther	6	I told her that she can either like my answer or not because I would not make up my professional expertise (#1); I smiled at her with a rather aggressive look (#4)
	Other	15	I wanted to prove her wrong (#2); I covered my shame with pride (#4); I accept myself how I am; I was self-confident (#6); It was due to the context, there wasn't much I could do (#8); If she attaches importance to something like that, then she is not a person I would attach importance to either (#9)

Note: In total, 20 shameful situations were analyzed. For the quotes, the participant number is given in parentheses.

VII. Conceptual Modeling Framework

Based on the theoretical foundation described in section III, we formulated a dynamic Bayesian network (DBN) modeling internal emotions (Fig. 2). The DBN integrates the GenIE and SMILE library (*bayesfusion.com*) into our *open-source framework SSI* which enables updating the DBN with real-time observations from multiple channels (facial expressions, movements, voice etc), as well as external context information. In general, two types of nodes exist. Blue nodes represent information updated based on observations in the DBN, red nodes represent information inferred by the DBN. When it comes to understanding and recognizing emotions, considering various social signals is essential, for example, facial expression, gaze, upper body orientation. Those signals represent the observable result of the underlying regulated emotion and applied regulation strategy. The dashed lines represent temporal edges enabling the simulation and prediction of more complex motion sequences. The regulated emotion, and its corresponding manifestation in social signals, is a result of a regulation strategy that also manifests in social signals. However, it is also possible that individuals do not apply any regulation strategy at all. In turn, both are influenced by the individual context. This information includes knowledge about different aspects of the interaction, for example, cultural background, personality, or intention. Also, the individual context of a person primarily determines which internal emotion the person is experiencing. In this paper, we mainly focus on shame. However, the DEEP method and the corresponding DBN can be applied to various internal emotions, like pride, admiration, and guilt. The internal emotion elicited by the individual context influences which regulation strategy a person is applying. The context, the regulation strategy, and the regulated emotion build the foundation for the verbalized introspection. This node represents a crucial aspect of the DEEP method. Gathering information about how individuals experienced certain situations and why they reacted in a certain

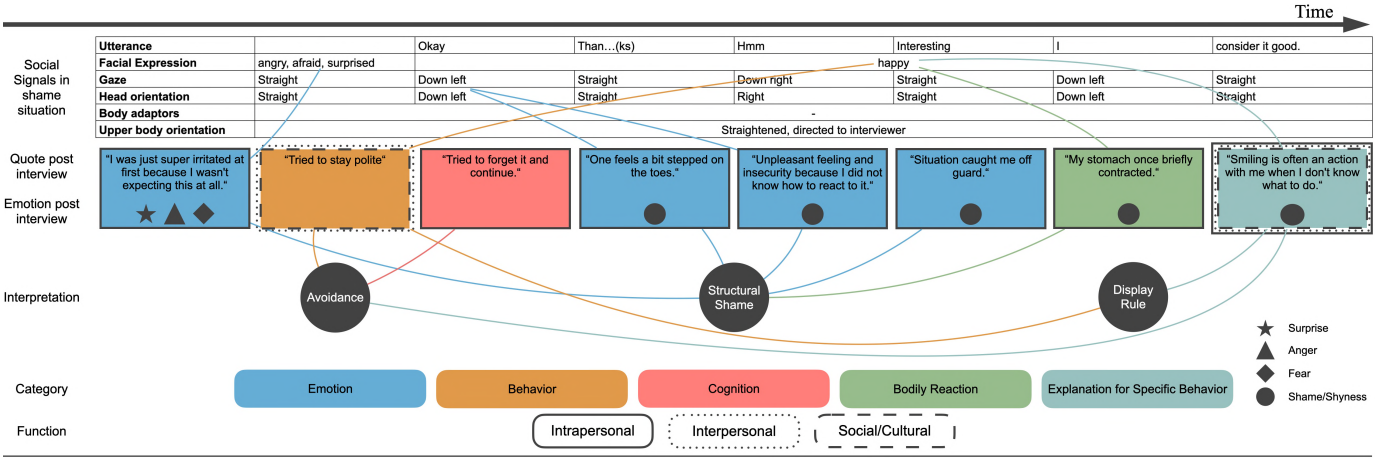

Figure 1: Analysis using the DEEP method for situation one ("A brief question before we start. Where did you get this outfit? Somehow it doesn't really fit you."), participant #3.

way ultimately helps to predict possible internal emotions reliably. The proposed network could be employed as an assistance system in psychotherapy or social training scenarios.

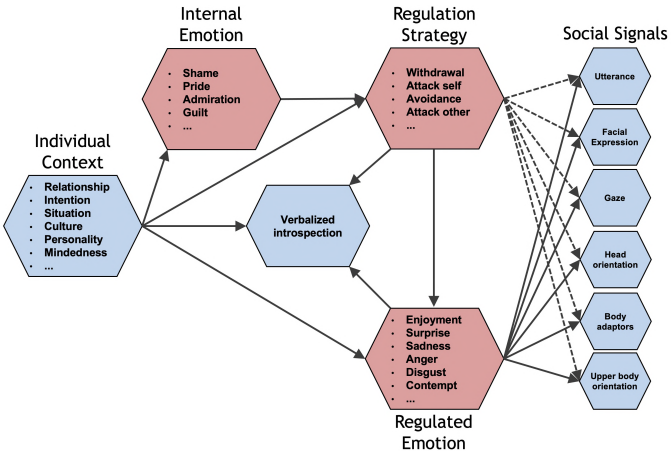

Figure 2: Schematic of a dynamic Bayesian network. Blue nodes (information updated based on observations); Red nodes (information inferred by the network); Solid edges (instantaneous causal effects), dashed edges (temporal causal effects).

VIII. Discussion

With this work, we introduce and apply a new multi-method approach to optimize the approximation of emotion understanding and modeling, the DEEP method. It combines four sources of information about one specific situation: social signals, context, self-reports, and theory-driven knowledge. We applied the introduced method to a situation in which participants experienced a shame elicitation in a job interview with a socially interactive agent. The questionnaire data indicates that the socially interactive agent can elicit shame in humans in the chosen situations. This replicates our previous study's finding showing once more that socially interactive agents can elicit an emotion of highly interpersonal nature [41]. This questionnaire data is supported by observed social signals of shame and shame regulation as well as self-reports: Raters assessed that shame was successfully induced in 90% of the situations. When talking about the situation afterward, participants mentioned on their initiative that they had experienced shame for 75% of the situations. Though most of the situations induced shame, it was not displayed openly. Our results show that in all situations, except one, shame is not reflected in the communicative component of emotions by the ashamed person. This finding is consistent with previous work showing that shame is often not observable [4], [5], [7]. Moreover, even though in most shame-eliciting situations, participants consciously felt shame, they wanted to maintain the relationship with the job interviewer. This demonstrates the crucial interpersonal function of shame, as it emerges when people note that they fail to meet social standards [42].

Additionally to shame itself, the study examined shame regulation strategies. Results indicate a discrepancy between self-assessment of regulation strategies usage in questionnaires and their observed occurrence. In self-assessment, the regulation strategy Attack Self was most commonly reported, whereas it was least applied in observed situations. This might indicate that context plays a more important role than people's general tendency to apply a specific shame regulation strategy.

The introduced DEEP method is a starting point for future research as it enables an understanding of internal emotions. Participants successfully verbalized their internal experience and confirmed that they spoke openly during the post interview. With minor adaptions, it is possible to apply the method to other emotions that are often regulated. Except the interpretation level (Fig. 1), the analysis is applicable without little adaptations to other emotions in other situations. Also, the post-interview questions were on a general level regarding internal experience, regulation strategies, bodily reactions, explanations for emotions, cognition, and behavior, as well as the connection between internal experience and social signals. However, possible emotion regulation strategies need to be adapted for the interpretation of the post interview answers as well as in the DBN.

IX. Limitations and Future Work

The DEEP Method is costly as it involves time-consuming data collection and analysis with trained interviewers and raters. Therefore, we are working on a questionnaire covering the semi-structured interview. As a method, a questionnaire could reduce the threshold of participants talking about a difficult emotional experience [44]. Moreover, applying automatic analysis tools could be an option to make the analysis process more efficient and more standardized.

For now, due to the time-consuming data analysis this method involves, its application is limited to one emotion and a small, pre-selected sample. If and how this procedure can be applied to individuals with a lower Psychological Mindedness score is a topic of future research. Theoretically, a lower score implies poorer ability to access and verbalize internal experiences, which results in limitations in perceiving, differentiating, or naming affect [38].

A major challenge for computational representation of internal emotional experience is expanding all group nodes (e.g., Fig.2, Individual Context, Regulation Strategy) into basal distinguished concept nodes. This requires an even deeper understanding of how concepts (e.g., culture, relationship, personality) interfere. More in reach is a more fine-grained presentation of internal states like appraisals, goals, motivations, and taking user actions as input. Existing DBN models (e.g., [19]) could be combined with the DEEP network schema.

X. Conclusion

This work presents the DEEP method of how to query individual internal emotional experiences and shows an approach how to represent such information computationally. Similar to other methods, the presented method is an approximation because measuring the "actual" emotional experience is daunting, as – by nature – it is internal and subjective. However, this work presents a first important step towards a deeper

understanding and modeling of emotions as internal, highly subjective experiences that are mostly not openly displayed. The emotion analysis with the DEEP method includes social signals, context, self-reports, and theory-driven knowledge.

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