

# Emotional Labor of Software Engineers

Alexander Serebrenik

Eindhoven University of Technology, The Netherlands, a.serebrenik@tue.nl

**Abstract**—The concept of emotional labor, introduced by Hochschild in 1983, refers to the “process by which workers are expected to manage their feelings in accordance with organizationally defined rules and guidelines”. For instance, judges are expected to appear impartial, nurses—compassionate and police officers—authoritative. While software development has been traditionally stereotyped as a nerdy “lone wolf” job less likely to induce emotional labor, nowadays software developers become more and more social, on the one hand, and are subject to increasing amount of behavioral expectations, e.g., formulated as codes of conduct.

In this position paper we stress that software developers are subject to emotional labor, envision how emotional labor can be identified based on emotion detection techniques applied in software engineering, suggest possible antecedents and consequents of emotional labor and discuss interventions that can be designed to address the challenges of emotional labor.

## I. INTRODUCTION

Software complexity is not solely of technological nature but also defined by people and processes. This means that special attention has to be dedicated to well-being and job satisfaction of people involved in creation of software.

The concept of emotional labor, introduced by Hochschild in 1983 [1], [2], refers to the “process by which workers are expected to manage their feelings in accordance with organizationally defined rules and guidelines”. For instance, judges are expected to appear impartial, nurses—compassionate and police officers—authoritative.

Software development has been traditionally stereotyped as a nerdy “lone wolf” job less likely to induce emotional labor [3]. However, nowadays software developers become more and more social [4] and are expected to more and more communicate with their team mates. Moreover, indirect evidence of emotional labor of software developers is abound. Already in 1991 Riedl et al. [5] reported that when debugging experienced developers manage their emotional display, e.g., by “appearing puzzled and confused, if necessary” to arouse interest of their fellow developers if those might provide help with the debugging task. This can be seen as an example of surface acting, notion closely related to the emotional labor when “an employee changes his or her verbal, facial, and bodily expression of emotions without modifying his or her underlying feelings” [6]. Furthermore, the same study of Riedl et al. [5] stresses that this behavior does not come naturally, should be learned and not learning is experienced as clumsiness and a sign of lack of a novice. A more recent example of an organizational rule prescribing emotional behavior is the Contributor Covenant<sup>1</sup> the most popular code of

conduct on GitHub [7], the major platform open-source software development. Examples of positive behavior encouraged by the Contributor Covenant include “gracefully accepting constructive criticism” and “showing empathy towards other community members”, i.e., to suppress negative emotions that might have been triggered by criticism and amplify positive emotions towards the colleagues. Codes of conduct in open-source projects are experienced as problematic by certain software developers as witnessed by the opposing efforts known as “No Code of Conduct”<sup>2</sup>. Finally, exhaustion related to emotional labor has been shown to be one of the most important variables explaining IT career abandonment [8].

While attention to emotions expressed by developers is growing within the software engineering research community, the existing literature suggests the problem of emotional labor of software developers is understudied: it has gained limited attention from applied psychologists working on emotional labor due to the aforementioned stereotyping [9], [10], and has not been studied by software engineering researchers.

## II. BACKGROUND

### A. Emotional labor

Numerous studies have related emotional labor to such outcomes as employee well-being, e.g., job satisfaction [3] and burnout, as well as to organizational well-being, e.g., interpersonal performance and task performance [11].

Morris and Feldman [12] operationalize emotional labor along four dimensions: frequency of emotional display, attentiveness to required display rules, variety of emotions required to be expressed and emotional dissonance, i.e., “the conflict between genuinely felt emotions and emotions required to be displayed” [13]. In particular, emotional dissonance has been reported to have a strong and consistent relation with work exhaustion and job satisfaction [14]. More recent meta-analysis of 95 studies of emotional labor [15] confirmed this observation and further stressed positive correlation of emotional dissonance with emotional exhaustion, depersonalization, psychological strain, and psychosomatic complaints. Furthermore, the authors observed that surface acting correlates with the same variables. In an additional meta-analysis study of 105 studies Kammeyer-Mueller et al. [6] concluded that stress/exhaustion levels were most substantially related to perceived negative display rules, i.e., perceived requirements to suppress negative emotions, while for job satisfaction there was a substantial negative relationship with surface acting.

<sup>1</sup><https://www.contributor-covenant.org/version/1/4/code-of-conduct.html>

<sup>2</sup><https://github.com/domgetter/NCoc>

### B. Emotional labor and software engineers

Software development has been traditionally seen as a job with few interpersonal requirements [3] and, therefore, less likely to induce emotional labor. Not surprisingly software developers are absent from the Hochschild's list of occupations most calling for emotional labor [1] that has influenced the emotional labor studies in the following years [16].

Several studies of emotional labor of software developers tend to lump them together with other kinds of IT professionals such as managers and support personnel [17], [18]. The studies show that for the IT professionals emotional dissonance predicts work exhaustion better than traditional predictors such as perceived workload; moreover, job satisfaction is influenced by work exhaustion and influences turnover intentions [17].

A complementary line of research focuses on software developers: the study of Rutner et al. distinguishes between different job types within IT [9], and of Günsel targeted software developers [10]. Rutner et al. show that "perceptions of positive display rules and levels of political skill differed by job type, but that perceptions of negative display rules, surface acting and deep acting did not", justifying individual studies of software developers as opposed to other IT job types [9]. Furthermore, the authors state that "programmers who, like other IT/IS professionals feel they should suppress negative emotional displays at work, also recognize the expectation to express positive emotions" [9]. Günsel has studied the relation between emotional labor of the developers and the resulting quality of software and observed "a positive relationship between the variety of emotions displayed during the projects, operational effectiveness and flexibility", while "emotional dissonance is found to be negatively associated with flexibility and responsiveness" [10].

### C. Emotions and Software Engineering

While emotional labor has rarely been studied in the context of software engineering (Section II-B), the broader topic of the study of emotions expressed by software engineers has recently gained significant attention from the software engineering research community [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29].

### D. Shortcomings of the existing approaches

The literature overview presented above suggests that there is a gap between the existing studies of emotional labor, on the one hand, and studies of emotions in software engineering, on the other hand, beyond the obvious differences in the target populations. First of all, while in the software engineering realm attention is being predominantly dedicated to detection of natural emotions *felt*, e.g., by analyzing texts created during the software development process, studies of emotional labor are mostly based on surveying subjects, i.e., focus on the emotional labor *perceived* or rarely on emotions *elicited* [30]. Second, software engineering studies focus on emotions as experienced at a given moment, *hic et nunc*, studies of emotional labor focus on broader concepts related to personality such as dispositional affects [6] or political

skill [9], or relatively extended time periods such as work shifts [31], [32] or their parts [33]. The momentary approach of Gabriel and Diefendorff is exceptional in this sense [30].

## III. EMOTION LABOR OF SOFTWARE DEVELOPERS

In this position paper we stress that software developers are subject to emotional labor, envision how emotional labor can be measured based on emotion detection techniques applied in software engineering, suggest possible antecedents and consequents of emotional labor and discuss interventions that can be designed to address the challenges of emotional labor.

### A. Identification of emotions

We start by discussing **detection of emotions** expressed by software engineers. As opposed to the existing techniques we aim at the momentary detection of the emotional dissonance as a gap between the emotion felt and emotion expressed. We investigate two groups channels used to communicate expressions: biometric channels that are more likely to reflect emotions genuinely felt and textual channels that are more likely to reflect emotions required to be displayed.

The first group of channels are physical reactions of the human body that can be measured by biometric devices [34]. Common biometric measurement techniques are electroencephalography (EEG), galvanic skin response measurement (GSR) and measurements obtained through an eye-tracker and face recognition techniques. EEG can measure valence of emotions, i.e., positive or negative, but also such cognitive processes as attention and perception [35]. Measuring cognitive processes is important for understanding the impact of emotional labor on job satisfaction and work exhaustion as they are likely to provide important confounding factors in the statistical models. Similarly, GSR can be used to measure arousal, emotional intensity and the direction of emotion [35]. Eye tracker can be used to fatigue and relaxation. Similarly to the cognitive processes, fatigue and relaxation can be expected to affect job satisfaction and work exhaustion. Tools for emotion detection based on face recognition [36] are capable of detecting such emotions as anger, contempt, disgust, fear, joy, sadness and surprise. We expect EEG, GSR and eye-tracker channels to be less regulated and therefore more adequately representing the emotions felt by the developers. Facial expressions are in general more regulated: non-surprisingly, Ekman and Friesen call the face "the major nonverbal liar" [37]. However, since software developers work in virtual teams we do not expect the emotional display rules to affect the facial expressions. Furthermore, despite the general deceptiveness of the facial expression micro-facial displays can provide cues as to the authentic emotion felt by an individual [37]. Since application of biometric measurements might be error-prone due to their invasive character and sensor drift/noise it will be carried out in the controlled experiment setting.

The second group of channels are the texts produced by software developers such as code review comments, issue tracker reports, or questions and answers on Q & A platforms. Several techniques have been proposed for detection of emotion in

software engineering texts: from a broad range of emotions (anger, fear, joy, love, sadness and surprise) in the work of Ortu et al. [26] to techniques focusing on detection of anger and its direction in the work of Gachechiladze et al. [27]; from models of discrete emotions [26], [27] to continuous valence-arousal-dominance model by Mäntylä et al. [22]. As opposed to the emotions sensed by means of biometric instruments, emotions as expressed in texts are communicated towards the interlocutors, and therefore are more likely to be subject to regulation either explicit via codes of conduct [7] or via the perceived notion of professional conduct. Therefore, emotions discovered by analyzing software engineering texts are more likely to reflect emotional display rules induced by the project, and therefore, depend on the project culture, e.g., whether it is formal or not [38], whether insults are acceptable or not [39].

Existing emotions questionnaires such as PANAS [40], LEAS [41], [42], DEQ [43] can be used for validation.

### *B. From emotions to emotional labor*

Next we plan to relate the individual measurements obtained by means of techniques developed in Section III-A to the conceptual framework of emotional labor, i.e., to propose an **operationalization of the emotional labor constructs in terms of the emotions identified**.

As a basis for such an operationalisation we consider the four dimensions of emotional labor proposed by Morris and Feldman [12], i.e., (1) frequency of emotional display, (2) attentiveness to required display rules, (3) variety of emotions required to be expressed and (4) emotional dissonance.

Frequency of emotional display has been operationalised as frequency of interactions [12] and further proposed to be measured as the number of interactions with different customers [44] or team mates [10]. Since software engineering texts have one or more addressees (e.g., individuals involved in reviewing a code change, or fixing a bug), ability to detect emotion in software engineering envisioned in Section III-A allows one also to quantify frequency of the emotional display. A similar argument can be made of the duration of emotional display, one of the components of the attentiveness to required display rules. The second component of the attentiveness to required display rules, i.e., intensity of the emotional display is related to the arousal component of the valence-arousal-dominance model of emotions [28], [29].

Variety of emotions required to be expressed calls for techniques capable of detecting different kinds of emotions, e.g., six discrete emotions detected by Ortu et al. [26] or the valence-arousal-dominance-based detection proposed Mäntylä et al. [22]. Results of the variety measurement can be compared with those obtained by the validated questionnaire [45].

As suggested in Section III-A emotional dissonance can be seen as a discrepancy between the emotion conveyed through the biometric channels and through the textual ones. To validate the emotional dissonance discovered in this way we would like to build on the existing psychological scales. However, emotional dissonance scale proposed by Cheung and Tang [46] is not suited for momentary evaluation. Therefore,

we take leaf from the book of Gabriel and Diefendorff [30] and for continuous rating, i.e., we will record the session, replay the recording to the participants and ask them to rate to what extent did they feel emotional dissonance at a given moment. Once emotional dissonance has been validated at the level of a single moment, one should investigate how those momentary values of emotional dissonance can be aggregated to extended periods of time (cf. aggregation of software metrics [47], [48]). The aggregated values can be then compared with the measurements on the emotional dissonance scale [46].

### *C. Antecedents and consequents of emotional labor in software engineering*

Identified emotional labor situations should lead to **understanding antecedents and consequents of emotional labor in software engineering**, i.e., aspects of developers' personalities, roles played, project organization etc that can impact different aspects of emotional labor and the ways emotional labor affects software products created by developers as well as developers' communities. This group of activities can convert the insights obtained so far into actions that can support software developers in their daily work.

1) *Antecedents*: Existing studies of emotional labor antecedents concerned such as personality variables extraversion and agreeableness [3] and positive/negative affectivity [6], and such demographics as gender [49], age [50], [51], race [52], [51] and national culture [53], [54]. All these variables can be expected to play a role also in the software engineering context. However, we focus on specifics of the software engineering task and keep personality and demographic variables as control. Specifically, we study the impact of a role played by a project contributor. Indeed, code reviewers, in particular, core code reviewers [55], [56], and bug triage masters can be expected to be involved in more interactions and more intensive interactions than regular developers. The same is likely to hold for project leaders and influential developers, closer to the center of the onion model [57], as well as for frequent contributors as opposed to the occasional ones [58]. Similarly, to roles we differentiate between analytic and synthetic software development tasks [59], e.g., identification of the bug cause vs. designing a bug fix, and study the impact of the kind of the task on emotional labor.

Furthermore, there seems to be little attention to the impact different organisational types can have on the emotional display rules, and, therefore, on the emotional labor. In software engineering, however, special attention has been given to identification of different organisational types, both in company-based and in open-source projects [38], [60]. We expect that distinguishing between different organisational types can help us to understand the differences between emotional display rules induced in different software development projects. In particular, we expect "community smells" [61], i.e., communication and collaboration anti-patterns reflecting undesirable community characteristics such as knowledge concentration or lack of communication, to incur negative emotions on the individuals involved and might increase emotional dissonance.

Finally, working on different kinds of artifacts might have different impact on the emotional state of the developer. Gunsel [10] has shown the system complexity has a moderating effect on the relation between emotional labor and software quality. However, since software developers' tasks involve working with software artifacts one could argue that the relation between system complexity and emotional labor is more intricate, as reviewing or modifying more complex code might not only be perceived as more intellectually challenging but also be expected to elicit more intensive emotions.

2) *Consequents*: We distinguish between two groups of consequents of interest: those related to the developers' community and to quality of the software produced.

First, earlier studies relating emotional labor to such consequents as job satisfaction, organizational attachment/turnover intention, emotional exhaustion [3], [15], [62] should be replicated on software developers. Furthermore, models based on emotional labor should be compared against alternative models for turnover [63], [64], [65], [66], [67], [68], [69], [70] and burnout [22], [71] designed for software engineers.

We also plan to investigate the impact of emotional labor on the software quality: preliminary results of Gunsel [10] suggest that such aspects of emotional labor as attentiveness, variety of emotions and emotional dissonance affect software quality as perceived by the developers with the project complexity moderating this relation. We would like to go beyond the perceived software quality to more objective measures of software quality such as the issue fixing time (cf. the study of Ortu et al. on affectiveness vs. issue fixing time [26] and of Jongeling et al. on the impact of the sentiment analysis tools in this context [72]). Furthermore, we would like to obtain a more refined understanding of the impact of emotional labor at individual activities such as introduction and removal of bugs, code smells and technical debt [73], [74], [75], [76]. We expect this relation between emotional labor and code quality since similar relations between code quality and singled-out community factors have been established in the past, e.g., socio-technical congruence [77], truck-factors [78], and newcomer contributions vs. bad smells [74].

Finally, we plan to study the impact of emotional labor on developers' productivity. The link between emotion and developers' productivity has been suggested in the past [28], [22]. Our previous work covered other variables affecting productivity [66]: they should be included in statistical modeling.

#### D. Designing interventions

Based on the understanding of the antecedents and the consequents of emotional labor of software engineers one can **design appropriate interventions**. Interventions can take place at the level of the project, of the individual developer, of their tasks and finally, at the level of the artifacts created. Some of the interventions can be supported by bots [79].

1) *Project*: If our expectation that community smells induce emotional labor then the corresponding mitigation techniques identified by Tamburri et al. [61], e.g., establishing a shared knowledge base ("social wiki") or appointing certain

developers to act as culture conveyors integrating previously disconnected sub-communities. Furthermore, recruitment policies can be designed or adapted to select candidates with self-expression congruent with emotional requirements [80]; if self-expression can at least partially be detected through software engineering texts as suggested in Section III-A such a congruence check can be integrated in the Social-Web candidate assessment advocated by Capiluppi et al. [81]. Finally, on a larger scale projects might consider changing their organisational type [38], [60], e.g., by opting for a more/less formal communication style.

2) *Individual developer*: Several emotional labor researchers suggested a possibility of offering trainings for emotion regulation, specifically for deep acting [11]. However, there are concerns related to hidden costs of deep acting [1] and to differences between deep acting learned through training as opposed to deep acting emerging naturally [11]. An alternative approach might be provided through implementation of mindfulness techniques [82], that have been shown to lead to significantly less emotional exhaustion and more job satisfaction. Application of mindfulness techniques is particularly promising since it has been recently successfully applied in the software engineering context as well [83].

3) *Task*: Different software development tasks can be expected to induce different kinds of emotional labor, e.g., the triage master is likely to have a higher frequency of emotional display. Similarly to recruitment task assignment should also take the risk of emotional dissonance into account, e.g., the triage master should not only be technically proficient and aware of responsibilities of individual subteams and developers, but also be capable of managing the aforementioned frequent emotional display. The same argument can be made for, e.g., the (core) code reviewers: one might wonder whether a recently observed high turnover of the core code reviewers [56] can be attributed to emotional labor.

4) *Artifacts*: Finally, if indeed as suggested in Section III-C1 maintaining or reviewing more complex systems induces more intensive emotions, this can be used as an additional argument supporting efforts reducing system complexity such as reengineering or refactoring.

## IV. CONCLUSIONS

In this position paper we have discussed the notion of emotional labor as studied in organizational psychology and argued that emotional labor is also experienced by software developers. We have outlined the ways emotional labor can be identified based on emotion detection techniques already applied in software engineering, as well as suggested possible antecedents and consequents of emotional labor. Based on the identified antecedents and consequents of emotional labor appropriate interventions can be designed.

## REFERENCES

- [1] A. R. Hochschild, *The Managed Heart Commercialization of Human Feeling*, 1st ed. University of California Press, 1983.
- [2] —, *The Managed Heart Commercialization of Human Feeling*, 3rd ed. University of California Press, 2012.

- [3] J. M. Diefendorff and E. M. Richard, "Antecedents and consequences of emotional display rule perceptions," *Journal of Applied Psychology*, vol. 88, no. 2, pp. 284–294, 2003.
- [4] M.-A. Storey, "The evolution of the social programmer," in *IEEE Working Conference on Mining Software Repositories*, June 2012, p. 140.
- [5] T. R. Riedl, J. S. Weitzenfeld, J. T. Freeman, G. A. Klein, and J. Musa, *What we have learned about software engineering expertise*. Berlin, Heidelberg: Springer Berlin Heidelberg, 1991, pp. 261–270.
- [6] J. D. Kammeyer-Mueller, A. L. Rubenstein, D. M. Long, M. A. Odio, B. R. Buckman, Y. Zhang, and M. D. K. Halvorsen-Ganepola, "A meta-analytic structural model of dispositional affectivity and emotional labor," *Personnel Psychology*, vol. 66, no. 1, pp. 47–90, 2013.
- [7] P. Tourani, B. Adams, and A. Serebrenik, "Code of conduct in open source projects," in *IEEE 24th International Conference on Software Analysis, Evolution and Reengineering*, 2017, pp. 24–33.
- [8] R. Colomo-Palacios, C. Casado-Lumbreras, S. Misra, and P. Soto-Acosta, "Career abandonment intentions among software workers," *Human Factors and Ergonomics in Manufacturing & Service Industries*, vol. 24, no. 6, pp. 641–655, 2014.
- [9] P. S. Rutner, F. Irani Williams, C. Campbell, and C. K. Riemenschneider, "The politics of emotion: Exploring emotional labor and political skill across job types within the it/is profession," *SIGMIS Database*, vol. 46, no. 3, pp. 52–73, Jul. 2015.
- [10] A. Gunsel, "The effects of emotional labor on software quality: the moderating role of project complexity," *Journal Of Global Strategic Management*, vol. 8, no. 2, pp. 101–115, 2014.
- [11] A. A. Grandey and A. S. Gabriel, "Emotional labor at a crossroads: Where do we go from here?" *Annual Review of Organizational Psychology and Organizational Behavior*, vol. 2, pp. 323–349, 2015.
- [12] J. A. Morris and D. C. Feldman, "The dimensions, antecedents, and consequences of emotional labor," *The Academy of Management Review*, vol. 21, no. 4, pp. 986–1010, 1996.
- [13] D. R. Middleton, "Emotional style: The cultural ordering of emotions," *Ethos*, vol. 17, no. 2, pp. 187–201, 1989. [Online]. Available: <http://www.jstor.org/stable/640321>
- [14] J. A. Morris and D. C. Feldman, "Managing emotions in the workplace," *Journal of Managerial Issues*, vol. 9, no. 3, pp. 257–274, 1997. [Online]. Available: <http://www.jstor.org/stable/40604147>
- [15] U. R. Hülsheger and A. F. Schewe, "On the costs and benefits of emotional labor: a meta-analysis of three decades of research," *Journal of Occupational Health Psychology*, vol. 16, no. 3, pp. 361–389, 1 2011.
- [16] A. S. Wharton, "The sociology of emotional labor," *Annual Review of Sociology*, vol. 35, pp. 147–165, 2009.
- [17] P. S. Rutner, B. C. Hardgrave, and D. H. McKnight, "Emotional dissonance and the information technology professional," *MIS Quarterly*, vol. 32, no. 3, pp. 635–652, 2008.
- [18] P. S. Rutner and C. K. Riemenschneider, "The impact of emotional labor and conflict-management style on work exhaustion of information technology professionals," *CAIS*, vol. 36, p. 13, 2015.
- [19] M. R. Wróbel, "Emotions in the software development process," in *International Conference on Human System Interactions*, June 2013, pp. 518–523.
- [20] A. Kolańska, A. Landowska, M. Szwoch, W. Szwoch, and M. R. Wróbel, "Emotion recognition and its application in software engineering," in *2013 6th International Conference on Human System Interactions (HSI)*, June 2013, pp. 532–539.
- [21] E. Guzman, D. Azócar, and Y. Li, "Sentiment analysis of commit comments in github: an empirical study," in *MSR*, 2014, pp. 352–355.
- [22] M. Mäntylä, B. Adams, G. Destefanis, D. Graziotin, and M. Ortu, "Mining valence, arousal, and dominance: Possibilities for detecting burnout and productivity?" in *MSR*. ACM, 2016, pp. 247–258.
- [23] A. Murgia, P. Tourani, B. Adams, and M. Ortu, "Do developers feel emotions? an exploratory analysis of emotions in software artifacts," in *Working Conference on Mining Software Repositories*. New York, NY, USA: ACM, 2014, pp. 262–271.
- [24] D. Pletea, B. Vasilescu, and A. Serebrenik, "Security and emotion: sentiment analysis of security discussions on github," in *MSR*, 2014, pp. 348–351.
- [25] N. Novielli, F. Calefato, and F. Lanubile, "The challenges of sentiment detection in the social programmer ecosystem," in *SSE @ FSE*, 2015, pp. 33–40.
- [26] M. Ortu, B. Adams, G. Destefanis, P. Tourani, M. Marchesi, and R. Tonelli, "Are bullies more productive? empirical study of affectiveness vs. issue fixing time," in *12th IEEE/ACM Working Conference on Mining Software Repositories, MSR 2015, Florence, Italy, May 16-17, 2015*. IEEE Computer Society, 2015, pp. 303–313.
- [27] D. Gachechiladze, F. Lanubile, N. Novielli, and A. Serebrenik, "Anger and its direction in collaborative software development," in *ICSE-NIER*, 2017, pp. 11–14.
- [28] D. Graziotin, X. Wang, and P. Abrahamsson, "Do feelings matter? on the correlation of affects and the self-assessed productivity in software engineering," *Journal of Software: Evolution and Process*, vol. 27, no. 7, pp. 467–487, 2015, jSME-13-0120.R2.
- [29] I. A. Khan, W.-P. Brinkman, and R. M. Hierons, "Do moods affect programmers' debug performance?" *Cognition, Technology & Work*, vol. 13, no. 4, pp. 245–258, Nov 2011.
- [30] A. S. Gabriel and J. M. Diefendorff, "Emotional labor dynamics: A momentary approach," *Academy of Management Journal*, vol. 58, no. 6, pp. 1804–1825, 2015.
- [31] B. Scott and C. Barnes, "A multilevel field investigation of emotional labor, affect, work withdrawal, and gender," *Academy of Management Journal*, vol. 54, no. 1, pp. 116–136, 2 2011.
- [32] E. Ouweneel, P. M. L. Blanc, W. B. Schaufeli, and C. I. van Wijhe, "Good morning, good day: A diary study on positive emotions, hope, and work engagement," *Human Relations*, vol. 65, no. 9, pp. 1129–1154, 2012.
- [33] D. J. Beal, J. P. Trougakos, H. M. Weiss, and R. S. Dalal, "Affect spin and the emotion regulation process at work," *Journal of Applied Psychology*, vol. 98, no. 4, pp. 593–605, 2013.
- [34] A. Fountaine and B. Sharif, "Emotional awareness in software development: Theory and measurement," in *2nd IEEE/ACM International Workshop on Emotion Awareness in Software Engineering, SEmotion@ICSE 2017, Buenos Aires, Argentina, May 21, 2017*. IEEE Computer Society, 2017, pp. 28–31.
- [35] J. L. Andreassi, *Psychophysiology: Human Behaviour and Physiological Response*. Psychology Press, 1999.
- [36] D. McDuff, A. N. Mahmoud, M. Mavadati, M. Amr, J. Turcot, and R. E. Kaliouby, "AFFDEX SDK: A cross-platform real-time multi-face expression recognition toolkit," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, CA, USA, May 7-12, 2016, Extended Abstracts*, J. Kaye, A. Druin, C. Lampe, D. Morris, and J. P. Hourcade, Eds. ACM, 2016, pp. 3723–3726.
- [37] P. Ekman and W. V. Friesen, "Nonverbal leakage and clues to deception," *Psychiatry*, vol. 32, no. 1, pp. 88–106, 1969.
- [38] D. A. Tamburri, P. Lago, and H. v. Vliet, "Organizational social structures for software engineering," *ACM Computing Surveys*, vol. 46, no. 1, pp. 3:1–3:35, Jul. 2013.
- [39] M. Squire and R. Gazda, "FLOSS as a source for profanity and insults: Collecting the data," in *48th Hawaii International Conference on System Sciences, HICSS 2015, Kauai, Hawaii, USA, January 5-8, 2015*, T. X. Bui and R. H. S. Jr., Eds., 2015, pp. 5290–5298.
- [40] D. Watson, L. A. Clark, and A. Tellegen, "Development and validation of brief measures of positive and negative affect: the PANAS scales," *Journal of Personality and Social Psychology*, vol. 54, no. 6, pp. 1063–1070, 1988.
- [41] R. D. Lane, D. Quinlan, G. Schwartz, P. Walker, and S. Zeitlin, "The levels of emotional awareness scale: A cognitive-developmental measure of emotion," *Journal of Personality Assessment*, vol. 55, pp. 124–134, 1990.
- [42] C. Subic-Wrana, M. E. Beutel, D. A. Garfield, and R. D. Lane, "Levels of emotional awareness: a model for conceptualizing and measuring emotion-centered structural change," *International Journal of Psycho-Analysis*, vol. 92, pp. 289–310, 2011.
- [43] C. Harmon-Jones, B. Bastian, and E. Harmon-Jones, "The discrete emotions questionnaire: A new tool for measuring state self-reported emotions," *PLoS One*, vol. 11, no. 8, pp. xx–xx, 2016. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4976910/>
- [44] J. M. Diefendorff, M. H. Croyle, and R. H. Gosserand, "The dimensionality and antecedents of emotional labor strategies," *Journal of Vocational Behavior*, vol. 66, no. 2, pp. 339–357, 2005.
- [45] C. M. Brotheridge and R. T. Lee, "Development and validation of the emotional labour scale," *Journal of Occupational and Organizational Psychology*, vol. 76, no. 3, pp. 365–379, 2003.
- [46] F. Y.-I. Cheung and C. S.-k. Tang, "The effect of emotional dissonance and emotional intelligence on workfamily interference," *Canadian Journal of Behavioural Science*, vol. 44, no. 1, pp. 50–58, 2012.

- [47] B. Vasilescu, A. Serebrenik, and M. G. J. van den Brand, "You can't control the unfamiliar: A study on the relations between aggregation techniques for software metrics," in *27th IEEE International Conference on Software Maintenance*, ser. ICSM. IEEE, 2011, pp. 313–322.
- [48] K. Mordal, N. Anquetil, J. Laval, A. Serebrenik, B. Vasilescu, and S. Ducasse, "Software quality metrics aggregation in industry," *Journal of Software: Evolution and Process*, vol. 25, no. 10, 2013.
- [49] J. Schaubroeck and J. R. Jones, "Antecedents of workplace emotional labor dimensions and moderators of their effects on physical symptoms," *Journal of Organizational Behavior*, vol. 21, no. 2, pp. 163–183, 2000.
- [50] J. J. Dahling and L. A. Perez, "Older worker, different actor? linking age and emotional labor strategies," *Personality and Individual Differences*, vol. 48, no. 5, pp. 574–578, 2010.
- [51] E. Kim, D. P. Bhawe, and T. M. Glomb, "Emotion regulation in workgroups: The roles of demographic diversity and relational work context," *Personnel Psychology*, vol. 66, no. 3, pp. 613–644, 2013.
- [52] L. Houston, "Keepin it real: race and performance ratings of positive displays," Master's thesis, Pennsylvania State University, 12 2012.
- [53] A. Grandey, A. Rafaeli, S. Ravid, J. Wirtz, and D. D. Steiner, "Emotion display rules at work in the global service economy: the special case of the customer," *Journal of Service Management*, vol. 21, no. 3, pp. 388–412, 2010.
- [54] J. A. Allen, J. M. Diefendorff, and Y. Ma, "Differences in emotional labor across cultures: A comparison of chinese and u.s. service workers," *Journal of Business and Psychology*, vol. 29, no. 1, pp. 21–35, Mar 2014.
- [55] A. Bacchelli and C. Bird, "Expectations, outcomes, and challenges of modern code review," in *ICSE*. IEEE Press, 2013, pp. 712–721.
- [56] P. van Wesel, B. Lin, G. Robles, and A. Serebrenik, "Reviewing career paths of the openstack developers," in *ICSME*, 2017.
- [57] K. Nakakoji, Y. Yamamoto, Y. Nishinaka, K. Kishida, and Y. Ye, "Evolution patterns of open-source software systems and communities," in *IWPSE*, 2002, pp. 76–85.
- [58] B. Vasilescu, A. Serebrenik, M. Geminne, and T. Mens, "On the variation and specialisation of workload – a case study of the Gnome ecosystem community," *Empirical Software Engineering*, vol. 19, no. 4, pp. 955–1008, 2013.
- [59] G. Schreiber, H. Akkermans, A. Anjewierden, R. de Hoog, N. Shadbolt, W. Van de Velde, and B. Wielinga, *Knowledge Engineering and Management: The CommonKADS Methodology*. Cambridge, MA: MIT Press, 1999.
- [60] D. A. Tamburri, P. Lago, and H. van Vliet, "Uncovering latent social communities in software development," *IEEE Software*, vol. 30, no. 1, pp. 29–36, Jan 2013.
- [61] D. A. Tamburri, P. Kruchten, P. Lago, and H. v. Vliet, "Social debt in software engineering: insights from industry," *Journal of Internet Services and Applications*, vol. 6, no. 1, p. 10, May 2015.
- [62] N. J. Yanchus, L. T. Eby, C. E. Lance, and S. Drollinger, "The impact of emotional labor on work–family outcomes," *Journal of Vocational Behavior*, vol. 76, no. 1, pp. 105–117, 2010.
- [63] E. Constantinou and T. Mens, "Socio-technical evolution of the ruby ecosystem in github," in *IEEE 24th International Conference on Software Analysis, Evolution and Reengineering, SANER 2017, Klagenfurt, Austria, February 20-24, 2017*, M. Pinzger, G. Bavota, and A. Marcus, Eds. IEEE Computer Society, 2017, pp. 34–44.
- [64] V. Midha and P. Palvia, "Retention and quality in open source software projects," in *Reaching New Heights. 13th Americas Conference on Information Systems, AMCIS 2007, Keystone, Colorado, USA, August 9-12, 2007*, J. A. Hoxmeier and S. Hayne, Eds. Association for Information Systems, 2007, p. 25.
- [65] A. Schilling, "What do we know about FLOSS developers' attraction, retention, and commitment? A literature review," in *47th Hawaii International Conference on System Sciences, HICSS 2014, Waikoloa, HI, USA, January 6-9, 2014*. IEEE Computer Society, 2014, pp. 4003–4012.
- [66] B. Vasilescu, D. Posnett, B. Ray, M. G. J. van den Brand, A. Serebrenik, P. Devanbu, and V. Filkov, "Gender and tenure diversity in GitHub teams," in *CHI Conference on Human Factors in Computing Systems*, ser. CHI. ACM, 2015, pp. 3789–3798.
- [67] A. Schilling, S. Laumer, and T. Weitzel, "Who will remain? an evaluation of actual person-job and person-team fit to predict developer retention in FLOSS projects," in *45th Hawaii International International Conference on Systems Science (HICSS-45 2012), Proceedings, 4-7 January 2012, Grand Wailea, Maui, HI, USA*. IEEE Computer Society, 2012, pp. 3446–3455.
- [68] M. Zhou and A. Mockus, "Who will stay in the FLOSS community? modeling participant's initial behavior," *IEEE Trans. Software Eng.*, vol. 41, no. 1, pp. 82–99, 2015.
- [69] B. Lin, G. Robles, and A. Serebrenik, "Developer turnover in global, industrial open source projects: Insights from applying survival analysis," in *12th IEEE International Conference on Global Software Engineering, ICGSE 2017, Buenos Aires, Argentina, May 22-23, 2017*. IEEE Computer Society, 2017, pp. 66–75.
- [70] M. Zhou, A. Mockus, X. Ma, L. Zhang, and H. Mei, "Inflow and retention in OSS communities with commercial involvement: A case study of three hybrid projects," *ACM Trans. Softw. Eng. Methodol.*, vol. 25, no. 2, pp. 13:1–13:29, 2016.
- [71] S. C. Sundaramurthy, A. G. Bardas, J. Case, X. Ou, M. Wesch, J. McHugh, and S. R. Rajagopalan, "A human capital model for mitigating security analyst burnout," in *Eleventh Symposium On Usable Privacy and Security, SOUPS 2015, Ottawa, Canada, July 22-24, 2015*, L. F. Cranor, R. Biddle, and S. Consolvo, Eds. USENIX Association, 2015, pp. 347–359.
- [72] R. Jongeling, P. Sarkar, S. Datta, and A. Serebrenik, "On negative results when using sentiment analysis tools for software engineering research," *Empirical Software Engineering*, Jan 2017.
- [73] A. F. Yamashita and L. Moonen, "Do developers care about code smells? an exploratory survey," in *20th Working Conference on Reverse Engineering, WCRE 2013, Koblenz, Germany, October 14-17, 2013*, R. Lämmel, R. Oliveto, and R. Robbes, Eds. IEEE Computer Society, 2013, pp. 242–251.
- [74] M. Tufano, F. Palomba, G. Bavota, R. Oliveto, M. Di Penta, A. De Lucia, and D. Poshyvanyk, "When and why your code starts to smell bad (and whether the smells go away)," *IEEE Transactions on Software Engineering*, vol. PP, no. 99, pp. 1–1, 2017.
- [75] G. Bavota and B. Russo, "A large-scale empirical study on self-admitted technical debt," in *Proceedings of the 13th International Conference on Mining Software Repositories, MSR 2016, Austin, TX, USA, May 14-22, 2016*, M. Kim, R. Robbes, and C. Bird, Eds. ACM, 2016, pp. 315–326.
- [76] E. Maldonado, R. Abdalkareem, E. Shihab, and A. Serebrenik, "An empirical study on the removal of self-admitted technical debt," in *Proceedings of the 33rd International Conference on Software Maintenance and Evolution, ICSME 2017, Shanghai, China, September 20-22, 2017*. IEEE, 2017, pp. xx–xx.
- [77] I. Kwan, A. Schröter, and D. Damian, "Does socio-technical congruence have an effect on software build success? A study of coordination in a software project," *IEEE Trans. Software Eng.*, vol. 37, no. 3, pp. 307–324, 2011.
- [78] G. Avelino, L. T. Passos, A. C. Hora, and M. T. Valente, "A novel approach for estimating truck factors," in *24th IEEE International Conference on Program Comprehension, ICPC 2016, Austin, TX, USA, May 16-17, 2016*. IEEE Computer Society, 2016, pp. 1–10.
- [79] M.-A. Storey and A. Zagalsky, "Disrupting developer productivity one bot at a time," in *Proceedings of the 2016 24th ACM SIGSOFT International Symposium on Foundations of Software Engineering*, ser. FSE 2016. New York, NY, USA: ACM, 2016, pp. 928–931.
- [80] R. W. Arvey, G. L. Renz, and T. W. Watson, "Emotionality and job performance: Implications for personnel selection," *Research in personnel and human resources management : a research annual*, vol. 16, pp. 103–148, 1998.
- [81] A. Capiluppi, A. Serebrenik, and L. Singer, "Assessing technical candidates on the social web," *IEEE Software*, vol. 30, no. 1, pp. 45–51, Jan 2013.
- [82] U. R. Hülshager, H. J. E. M. Alberts, A. Feinholdt, and J. W. B. Lang, "Benefits of mindfulness at work : the role of mindfulness in emotion regulation, emotional exhaustion, and job satisfaction," *Journal of Applied Psychology*, vol. 98, no. 2, pp. 310–325, 1 2013.
- [83] B. Bernárdez, A. Durán, J. A. Parejo, and A. Ruiz-Cortés, "An experimental replication on the effect of the practice of mindfulness in conceptual modeling performance," *Journal of Systems and Software*, 2016.