A Taxonomy of Situations within the Context of Risk Analysis

Adam Szekeres, Einar Arthur Snekkenes
Norwegian University of Science and Technology - NTNU
Gjøvik, Norway
adam.szekeres, einar.snekkenes@ntnu.no

***Abstract*—Prediction of deliberate human decisions with potential negative impact on others would have great practical and scientific utility. The Conflicting Incentives Risk Analysis (CIRA) method defines risk as a result of misaligned incentives between various stakeholders. The method makes predictions based on action desirability from the perspective of the individual in the position to implement the action. Therefore, in order to assess action desirability it is necessary to characterize stakeholders and their perceptions about the situation as well. While classification systems and taxonomies related to stakeholder attributes are well-established, systematic classifications of situational aspects are underdeveloped in the literature. Therefore, the main objective of this paper is to present a classification of situational variables in the form of a taxonomy capturing key situational features that exert influence on decision-makers. The development of the taxonomy begins with mapping two major types of risks distinguished in the CIRA method to relevant psychological constructs. The principled, systematic development of dilemmas enabled by the taxonomy allows researchers to investigate the predictability of stakeholder behavior which may result in various types of risks. The taxonomy is extensible, thus additional concepts and variables can be included depending on the needs of the analysis and according to future developments within the fields of psychology and information security.**

I. Introduction

Frederiksen's overview on approaches for predicting individual behavior explains that the need for predicting the behavior of single individuals arose and received a great deal of scientific attention during the cold-war era following the realization that an individual could initiate economic and military actions with serious negative consequences for millions of people [1]. In a world characterized by increasing levels of interconnectedness and inter-dependency, where decision-makers and the people affected by critical decisions are linked together and separated by layers of complex technical solutions, there is a pressing need to understand and predict key decision-makers' behavior. The Conflicting Incentives Risk Analysis (CIRA) method was developed for the analysis of risks arising from deliberate human decisions, and re-conceptualizes risk, within the domains of information security and privacy [2]. CIRA requires the identification of two classes of stakeholders, their relevant utility factors and the actions that can be implemented to describe the risk situation. Stakeholder classes are: *Strategy Owner:* the person capable of executing an action and *Risk Owner:* the person(s) enjoying the benefits/suffering the consequences of the actions. To analyze risks resulting from intended human actions which impact the utility factors of the respective stakeholders CIRA asks the question from the perspective of the *Risk Owner*: are we in equilibrium? More specifically, CIRA analyzes situations such as the following: can those that are in the position to implement an action obtain a significant benefit and at the same time cause damage to the *Risk Owner* (in terms of loss of utility)? Such situations are defined as *Threat Risks*. *Opportunity Risks* may result from (in)actions that one can reasonably expect that the *Strategy Owner* should take, but for which the *Strategy Owner* would have to take a loss in utility and the *Risk Owner* has the prospect of a gain [3]. There is a need to enhance the method's applicability by including relevant situational and personality variables which enable predictions with respect to the Strategy Owner's choices in strategic settings. This work contributes to CIRA's ongoing enhancement by proposing a taxonomy of situations -built on existing literature and extending on established results- which enables the systematic manipulation of relevant situational variables for effective dilemma development. The dilemmas created by utilizing the taxonomy facilitate further research attempts to test and fine-tune CIRA's predictive capabilities.

The paper is structured as follows: Section II provides an overview about existing research work related to the overall objectives and about previous attempts for developing taxonomies of situations. Section III explains the development of the taxonomy in detail, Section IV presents a set of dilemma examples to demonstrate the usefulness of the taxonomy, Section V provides the evaluation of the taxonomy. Section VI gives a summary about the relevance and limitations of the proposed taxonomy and identifies venues for further improvements and Section VII concludes the work.

II. Related work

A detailed overview is provided on the potential approaches for behavior prediction from a psychological perspective in [1]. It is noted that the scientific perspective is more concerned with generalizations that hold for a large number of people rather than for a single individual, with the exception of clinical applications. The method which relies on individual differences (e.g. aptitude, personality, attitudes, personal history) works well when comparative statements need to be

ISSN 2305-7254

made about the probable performance of many individuals. However, the method fails when the problem is to predict a single individual's behavior across situations over time, since "individual differences" do not exist for the specific person (i.e. lack of comparability). Three potential solutions are presented for the problem of individual behavior prediction:

1) **Personnel psychologist's approach:** requires a measure of a criterion performance *y*, and at least one measure of personal characteristic *x*, which is correlated with *y*. The regression of *y* on *x* provides the prediction of criterion performance. Similarly, an analogous procedure would require criterion behaviors measured on many occasions and the predictor variables would have to be personal characteristics that vary over time.
2) **Situational variables approach:** the criterion performance *y* is predicted by ratings of situational variables which correlate well with the criterion variable over occasions. This method would require extensive assessments of situations across settings.
3) **Clinician's approach:** relies on careful study of the individual and tries to predict (using subjective evaluation) the behavior in previously unobserved situations. This approach is often utilized in clinical settings, for parole decisions, assessment of re-offending behavior, etc. The clinician makes a judgment which implicitly states how the subject with a given set of personal characteristics placed in a specific situation will likely behave. Thus, the clinician's judgment implies interactions between personal and situational variables.

The first two approaches (i.e. personnel psychologist's, situational variables) correspond to the mechanical approach, while the third one corresponds to the clinical approach in the literature. For detailed discussions about the relative superiority of the mechanical prediction approach over the clinical approach see: [4], [5], [6]. There has been an increased research interest in the interactionist attempts to the behavior-prediction problem (formalized versions of the clinical judgment) but their ineffectiveness might be due to the fact that there is a lack of classification of situations that would enable a systematic way of conceptualizing situations and situational variables. Thus, taxonomies that have been very efficient in classifying variables related to individual differences need to be developed in the domain of situations as well. Taxonomies would allow for a satisfactory and systematic conceptualization of the environment by dimensional analysis of the stimulus variables [7]. "The purpose of a taxonomy is twofold: (1) to structure a domain of objects in order to efficiently handle its information content, and (2) predictive power; if we know that an object belongs to a particular taxon we can immediately predict a number of characteristics that it is expected to possess" [8]. Taxonomies are widely utilized across disciplines for organizing information in a systematic way and for presenting it efficiently and coherently. Taxonomies have been developed to classify: cognitive skills [9], personality attributes [10], information system artifacts [11], network attacks [12], clustering algorithms [13], intrusion detection systems [14], privacy violations [15], etc.

The following overview focuses on attempts for systematically identifying psychologically relevant situational dimensions and for developing taxonomies of situations. The review is restricted to taxonomies of situations constructed within the field of psychology focusing on the individual's perception of the situation. The literature search was conducted with the keywords "taxonomy" AND "situations" in the title in the following databases: Google Scholar, ScienceDirect. Research papers available in English were considered for inclusion. Furthermore, based on the review in [8] additional taxonomies are presented that were otherwise inaccessible in full text. The overview's primary purpose is to demonstrate previous approaches and theoretical considerations, without aiming for completeness. Comprehensive taxonomies are presented first, which aim at capturing influential situational factors across various domains, followed by domain-specific taxonomies which are characterized by a narrower scope, based on the context of application. Table I presents a classification of the articles included in this overview, based on the breadth of the situations analyzed and approaches for development.

TABLE I. CLASSIFICATION OF EXISTING TAXONOMIES OF SITUATIONS BASED ON THE BREADTH OF SITUATIONS INCLUDED AND THE APPROACHES CHOSEN FOR TAXONOMY DEVELOPMENT. THE LOCATION OF THE TAXONOMY DEVELOPED IN THIS PAPER IS MARKED WITH **X** AMONG THE EXISTING TAXONOMIES OF SITUATIONS.

		Breadth	
		Comprehensive	*Domain-specific*
Approach for development	*Theoretical*	[16], [17]	[18], **X**
	Empirical	[19], [20], [21], [22], [23], [24]	[25], [26], [27], [28], [29], [30]

A. Comprehensive taxonomies

An early taxonomy of social situations was developed theoretically [16], guided by ideas from ecological psychology and it identifies seven classes of behavioral settings across various domains: (1) joint working; (2) trading; (3) fighting; (4) sponsored teaching; (5) serving; (6) self-disclosure; (7) playing. According to the theory every person is capable of objectively categorizing a given situation into one of the seven classes and behaves according to the contextual, cultural and role requirements invoked by the given situation.

The Atlas of Interpersonal Situations [17] focuses on the interpersonal aspects (as opposed to impersonal features, e.g. physical) of situations by developing a framework systematically and theoretically. The framework includes 21 frequently occurring situations that can be discriminated and classified according to their conceptual properties, thus the taxonomy does not aim to achieve completeness in terms of all potential situations but aims to focus on factors that are most likely to dominate the individual's attention and behavior according to interdependence theory. Interdependence theory provides a tool for analyzing situations in which individuals influence each

other's outcomes. The atlas provides detailed analyses for the 21 situations through interdependence theory's lens.

A taxonomy is constructed from a factor analysis of respondents' descriptions about the relevant situational traits (i.e. persons involved, time and place of the event), feelings and behaviors [19]. The analysis of four participants' responses generated four different taxonomies for each respondent but aggregating them together resulted in the following six situational dimensions: (1) Home and family; (2) Friends and peers; (3) Relaxation, recreation and play; (4) Work; (5) School and (6) Alone.

The lexical approach was utilized by [20] for the development of an empirical taxonomy which contains a broad range of objectively defined (i.e. ignores individual differences) situational attributes generated from nouns used for the description of various situations. The cluster analysis revealed the following ten situation dimensions: (1) interpersonal conflict; (2) joint working, exchange of thoughts, ideals and knowledge; (3) intimacy and interpersonal relations; (4) recreation; (5) travelling; (6) rituals; (7) sport; (8) excesses; (9) serving; (10) trading.

The joint taxonomy of traits and situations [21] aims to consider how traits get expressed in various situations, and how situations differ in the type and number of traits that are expressible in them. Based on the Big Five trait taxonomy, situations were generated by participants considering the expression of the given trait in various situations. A reduced set of situations was evaluated by the probability of a trait-related behaviors' occurrence. The principal component analysis revealed five situation dimensions named as: (1) adversity; (2) amusement; (3) positioning; (4) conduct; (5) daily routine.

Another taxonomy using the lexical approach on Chinese idioms is presented in [22]. Based on participant's judgment of the idioms content it was revealed that goal processes (i.e. what impact a given situation had on the goals of the people described in the idioms) was a major distinguishing factor between situations. On the broadest level, people distinguish situations along the success-failure dimensions (the situation's impact on the goals), while at more fine-grained level 17 factor solutions were deemed best, based on various statistical considerations.

A cross-cultural (U.S. and Japan) study using the Riverside Situational Q-sort method shows preliminary evidence that both cultures assess the importance of two dimensions similarly when evaluating situations [23]. The relevant dimensions identified in the study are: (1) presence of a member of the opposite sex; (2) and the experience of being criticized by others.

The CAPTION-model presented in [24] is one of the latest attempts for constructing a comprehensive situation taxonomy through factor analysis of in-situ qualitative descriptions provided by respondents (i.e. using the lexical approach). The basis for the work was the lexical corpus of U.S. movie subtitles with 51 million words, which was screened by Amazon Turk workers. The study constructs a framework by identifying key similarities and differences among a wide collection of situation characteristics. CAPTION refers to the 7 situation dimensions which emerged after applying several data-analytic techniques: (1) Complexity; (2) Adversity; (3) Positive Valence; (4) Typicality; (5) Importance; (6) Humor; (7) Negative Valence. Additionally, the study presents the assessment of the psychometric properties (e.g. internal factor structure, convergent-discriminant validity, predictive validity) of the measure developed from the taxonomy.

B. Domain-specific taxonomies

The theoretically constructed, domain specific taxonomy of high-risk situations for relapse in relation to alcohol abstinence was proposed in [18]. The taxonomy is built from accumulated research results to enable the identification and classification of situations increasing the probability of a relapse. It identifies five sub-categories under the "Intrapersonal determinants" (e.g. Urges and temptations), and three sub-categories within the "Interpersonal determinants" dimension (e.g. Social pressure). The taxonomy allows practitioners to develop cognitive-behavioral interventions matching specific categories, to which patients may be exposed. Furthermore, the taxonomy enables the targeted training of specific coping strategies needed to deal with specific high-risk situations.

The taxonomy presented in [25] organizes a total of 11 situations according to their potential for evoking anxiety in subjects. The taxonomy is based on factor analysis of responses and distinguishes three classes of situations based on their anxiety-provoking potential: (1) interpersonal situations; (2) dangerous situations without social aspects; (3) ambiguous situations. The selection of situations was guided by intuitive attempts to present respondents with a variety of situations that most people have experience with.

Another empirically developed situational taxonomy is presented in [26], based on similarity judgments of situations in an academic setting. The hypothesis upon which the study builds supposes that people distinguish between situations along unique cognitive dimensions, which raises the problem that the structure is flexible and changes across domains between individuals as well as within individuals. The factor analysis of participants' responses identified 5 dimensions: (1) positive situations; (2) negative situations; (3) passive situations; (4) social situations; and (5) active situations.

The empirical taxonomy in [27] is based on the idea that the similarity of situations should be assessed on the basis of the elicited behaviors. The taxonomy is created by using a three-dimensional data matrix which consists of individuals, situations, and elicited behaviors. The matrix is collapsed across people, thus ignoring individual differences and is factor analyzed to reveal clusters of situations invoking similar behaviors. The domain of the taxonomy is based on hypothetical work tasks that respondents had to solve assuming a chief executive role. The following six factors emerged in

this specific taxonomy of executive tasks: (1) evaluation of procedures for accomplishing organizational goals; (2) routine solution; (3) solution of inter-organizational problems; (4) solution of personnel problems; (5) change in policy; (6) conflicting demands on staff time.

Individual's perception about the psycho-social features (i.e. perceived climates) of various social environments form the basis of the taxonomy in [28]. The taxonomy implicitly takes into account the personality of the respondents and it identifies three dimensions: (1) relationship; (2) personal development; (3) system maintenance and system change.

The taxonomy presented in [29] is based on the appropriateness of behaviors in various situations. The situations and behaviors were generated from university students' diaries, and respondents had to judge the resulting combinations in terms of the appropriateness of the behavior in various situations. The matrix was cluster-analyzed and resulted in the following four homogeneous situation-clusters based on their specific behavioral content: (1) park, sidewalk, football game; (2) dating, family dinner, movies; (3) bar, elevator, job interview, restroom; (4) class, church, bus, dorm lounge, own room.

A taxonomy of social episodes is presented in [30], which is based on the individual's perception of recurring interaction sequences, which are defined by symbolic, temporal and physical boundaries. A student and a housewife sample generated lists of adjectives describing their interactions over the course of a day which were used to form the hypothetical dimensions. The relatedness of the episodes was Q-sorted by participants and resulted in a two-dimensional configuration for housewives and a three-dimensional configuration for students. The episode structure according to the perception of the housewives is governed by (1) perceived intimacy, involvement, and friendliness of episode; (2) subjective self-confidence, or competence of the actors related to the episodes. For the student sample the following structure emerged: (1) involvement; (2) pleasantness; (3) knowledge about how to behave.

Based on the overview of existing attempts at developing taxonomies of situations a few things may be noted: the environment and situations are rich (i.e. abundant with features), which results in a high degree of incompatibility across taxonomies. This may reflect the complexity associated with situational aspects; the difficulty associated with objectivist descriptions of situational attributes which exert influence on the behavior irrespective of personality characteristics; and that the goals of the taxonomy (i.e. application domain), as well as the personal history of the researchers largely influences which situational aspects, methods and analytical procedures are evaluated as appropriate for solving a given research problem. Despite efforts aiming for comprehensive situational taxonomies the field is still characterized by perplexity. Existing taxonomies vary significantly in their perspectives on the relevant situational features. The overview suggests that a feasible approach for developing a practically useful situational taxonomy starts by investigating the domain of application extensively. Next, it should consider existing research results that capture specific situational features assumed to be relevant within the field; and finally synthesizes the results in a concise manner.

III. Development of the Proposed Taxonomy

Key requirements for the taxonomy are as follows:

1) to systematically categorize situations based on a subset of their attributes, which have been demonstrated to exert influence on decision-makers.
2) to enable the development of dilemmas which can be used for testing and improving the predictive capabilities of CIRA.
3) to operationalize risk concepts in CIRA (i.e. Threat/Opportunity Risk) and connect them to existing research traditions.

This section describes the method of the taxonomy development, starting by mapping CIRA's risk concepts and major psychological constructs. A definition for each dimension's meaning with reference to previous research results is provided and the section ends with the presentation of the proposed taxonomy.

A taxonomy classifies objects of interest (such as animals and plants, etc.) into groups within a larger system according to their similarities and differences [31]. However, classification systems are always somewhat arbitrary [1]. A taxonomy which successfully classifies objects may have useful implications improving theories and facilitating discoveries (i.e. the periodic table of elements, Carl Linnaeus's taxonomies). The most widely used techniques for empirically developing taxonomies in the field of individual differences, (e.g. abilities, intellect, personality) are factor analysis or clustering analytic methods that rely on a vector of attribute scores for individuals. For cluster analysis the measure of similarity for a pair of individuals is not the correlation coefficient (as opposed to inverse factor analysis), but the number of shared features, an aggregated similarity judgment of objects, the Euclidean distance between two vectors or any other sophisticated, generalized distance metric [1]. Taxonomies, however can be constructed by theoretical considerations as well. Such taxonomies can be built by taking all the possible combinations of identified attributes, while keeping in mind that this method may result in a large number of categories, or categories that do not exist in real life [1].

The present development followed the theoretical approach by identifying and combining relevant situational attributes based on existing and related research results. During the development, the following factors were considered:

- the domain of application for the proposed taxonomy (i.e. human-related risk analysis in the field of information security and privacy as defined by the CIRA method's purpose),
- theoretical considerations and analysis of the underlying

mechanism of decision-making relevant for the risk concepts identified in CIRA,

- compatibility of existing and well-established psychological constructs with CIRA concepts,
- existing empirical results about relevant situational dimensions for decision-making associated with the previously identified concepts and constructs.

Taken together, these considerations lead to a mapping between two central concepts defined within CIRA and established psychological constructs: **Threat risk** was mapped to the concept of a **Moral dilemma**, and **Opportunity risk** was mapped to the construct of **Altruism**. The mapping enables the operationalization of the two distinct risk types as established psychological constructs for research purposes, however other operationalizations are also conceivable. The mapping enabled the identification of existing research results in these separate domains of scientific inquiry which were combined for the construction of the taxonomy. The initial conceptual model of the proposed taxonomy of situations and mapping of psychological constructs to key CIRA concepts is presented in Fig. 1. Further steps of the development of the taxonomy are presented below by presenting additional dimensions, with their relevance supported by empirical results and theoretical considerations.

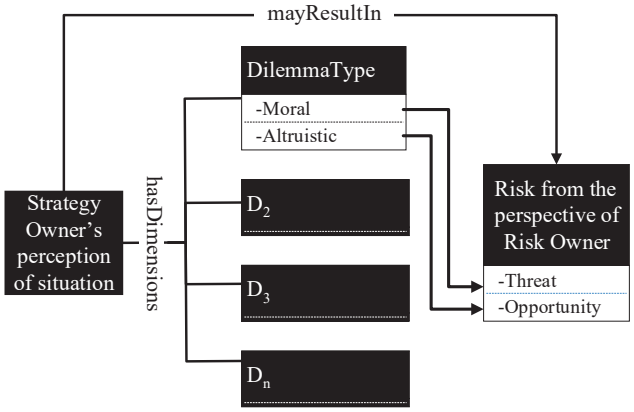

Fig. 1. Initial conceptual model of the situation taxonomy with mapping of psychological constructs to risk types distinguished by CIRA.

A. DilemmaType

The dilemma type dimension was developed as follows: the moral dilemma questionnaire (used in cognitive neuroscience for the investigation of dual process theories in moral judgments) presented in [32] served as the starting point for the development of the taxonomy. The original objective of the questionnaire was to enable investigations into the neural correlates of moral decision-making (i.e. Is it acceptable to inflict harm upon a victim for the benefit of others?). Moral philosophers have identified discrepancies between responses given to dilemmas that are identical in terms of their objective outcomes, but differ in the level of engagement required by the decision-maker (the prototypical dilemmas are known as the *Trolley dilemma* and the *Footbridge dilemma* see: [32]). These dilemmas are characterized by their difficulty which is attributed to the conflict between dissociable psychological processes. These processes yield different solutions to the problem based on a utilitarian (i.e. consequentialist) and a non-utilitarian (emotion-driven, deontological, rule-based) assessment [33]. These dilemmas are especially hard since, no matter which solution is selected, the other system will be dissatisfied [34]. The original dilemmas [32] were reused in several studies and got refined over time to allow more detailed investigations. Altruistic dilemmas proposed in this taxonomy represent counterparts of moral dilemmas. Based on the structural features of moral dilemmas, altruistic dilemmas were introduced, in which the respondent has to decide whether to implement a self-sacrificing act for the benefit of others. The crucial difference is that altruistic choices require that the decision-maker take a loss in a broad sense (e.g. in terms of money, time, health, etc.) in order to provide a benefit for others (in a broad sense as well). Thus, for altruistic situations conflict arises between immediate self-interest and between the potential benefit provided for others. Inspiration was taken from the Altruistic Personality Scale presented in [35], but the dilemmas developed using the proposed taxonomy do not aim to assess altruism as a personality trait. A third dilemma type was also considered (previously termed as non-moral dilemmas in [32]) which require the weighing of costs and benefits for the decision-maker only, thus dilemmas in this category have no influence on others, except the decision-maker. The proposed taxonomy identifies the following three *DilemmaTypes*: **Moral**, **Altruistic** and **Rational**.

B. Context

Context refers to salient features of the environment that may impact behavior in predictable ways by activating short-term goals in a given role. The inclusion of this dimension is supported by evidence that there is significant within-person variability of expressed and experienced personality states across situations throughout extended periods of time [36] and across roles [37], [38]. Some proposed models aim at capturing and integrating how social roles are associated with different types of short-term goals which represent important aspects of situations which in turn exert influence on expressed personality traits [39], [40], [41]. Management of role requirements in various work settings is a central topic in economics and is known as the principal-agent problem. Research in the field focuses on ways to achieve alignment between the interests of workers and employers using proper incentives [42]. In its current form the proposed taxonomy distinguishes between two *Contexts*: **Private** and **Professional**.

C. PhysicalDistance

The physical distance dimension matches with the classification used in the refined Greene-dilemmas [33]. It has been

shown that impersonal dilemmas (i.e. there is no physical contact with the victim) increases the tendency to use the utilitarian decision-making approach compared to personal dilemmas (i.e. harm is directly inflicted upon somebody). The distinction applies to dilemmas in the *Altruistic* category such that altruistic personal dilemmas imply that a benefit is provided to someone else through direct physical interaction, while impersonal altruistic dilemmas introduce physical separation between the decision-maker and the potential beneficiary. The *Rational* dilemma type has no corresponding *PhysicalDistance* dimension, since it captures decisions that require pure cost-benefit analysis, which have no direct or indirect impact on others than the decision-maker. The taxonomy identifies the following levels of the *PhysicalDistance* dimension: **Personal** and **Impersonal**.

D. LevelOfConflict

The updated set of moral dilemmas in [33] distinguishes between high- and low-conflict dilemmas only in the case of personal dilemmas. High-conflict dilemmas mean that the two parallel evaluative processes provide contradictory answers, while in general for low-conflict dilemmas the suggestion from the rule-based (deontological) system overrides the utilitarian system's suggestion or they are in alignment. The original categorization is now extended to the **Impersonal** level such that **Impersonal** High-conflict dilemmas would entail an indirect loss inflicted upon others for a greater good, while impersonal low-conflict dilemmas would require an indirect loss inflicted upon others for a selfish gain in case of moral dilemmas. For altruistic choices the *LevelOfConflict* signifies a high or low cost for the self, given that the action is initiated. *Rational* dilemmas have no corresponding *LevelOfConflict* dimension. The taxonomy identifies the following levels within the *LevelOfConflict* dimension: **High** and **Low**.

Fig. 2 shows the overall structure of the proposed taxonomy, which enables the systematic manipulation of situational variables thus allowing the construction of specific dilemmas for each leaf node. This results in a taxonomy with 18 leaf nodes in total. The main objective of the taxonomy is that it provides a structured, principled way to develop dilemmas which can be used to test and fine-tune CIRA's predictive capabilities.

IV. Illustrative scenarios

For each leaf node two different dilemmas were constructed to enable the prediction of subject's responses (36 dilemmas in total). For the purpose of demonstration and due to space limitations only three dilemmas are presented here. One of them -which was previously developed in [32]- is used for demonstrating how existing dilemmas can be categorized according to the taxonomy; and two new dilemmas demonstrate how the taxonomy enables the creation of novel dilemmas in a systematic manner. Table II provides an overview about the dilemmas by specifying the leaf-node (category), the identified Risk Owner(s), and the corresponding type of risk.

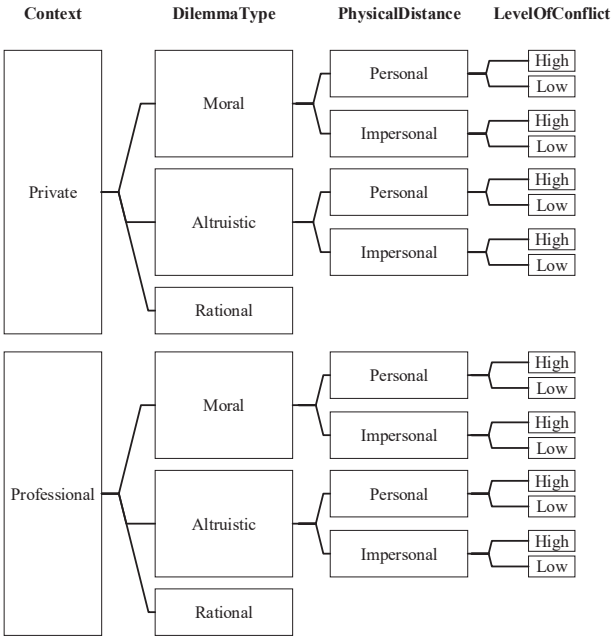

Fig. 2. Structure of the proposed taxonomy of situations.

In an experimental setting a respondent takes the role of the Strategy Owner. The dilemmas are identified by their leaf-nodes, using the following abbreviations: Priv. (**Private**), Prof. (**Professional**) for *Context*; M (**Moral**), A (**Altruistic**), R (**Rational**) for *DilemmaType*; P (**Personal**), I (**Impersonal**) for *PhysicalDistance*; H (**High**), L (**Low**) for *LevelOfConflict*.

A. Classification of an existing dilemma

Categorization of existing dilemmas and real-world situations can be achieved by analyzing the case according to the taxonomy's structure. By identifying the dimensions and the levels associated with the dimensions it is possible to assign cases into a unique category specified by the taxonomy. This is illustrated by the Crying baby dilemma from [32], which can be placed into the category defined by the **Private** *Context*, **Moral** *DilemmaType*, **Personal** *PhysicalDistance* and **High** *LevelOfConflict* dimensions. The dilemma goes as follows:

Enemy soldiers have taken over your village. They have orders to kill all remaining civilians. You and some of your townspeople have sought refuge in the cellar of a large house. Outside you hear the voices of soldiers who have come to search the house for valuables. Your baby begins to cry loudly. You cover his mouth to block the sound. If you remove your hand from his mouth his crying will summon the attention of the soldiers who will kill you, your child, and the others hiding out in the cellar. To save yourself and the others you must smother your child to death. Is it appropriate for you to smother your child in order to save yourself and the other townspeople?

TABLE II. DILEMMA EXAMPLES CONSTRUCTED BY USING THE TAXONOMY. RISK OWNER(S) AND THE TYPE OF RISK EXPERIENCED IS SPECIFIED IN ADVANCE. THE DILEMMA MARKED WITH * IS TAKEN FROM [32].

Leaf-node code	Risk Owner(s)	Type of risk (Threat/Opportunity)	Title of dilemma
Priv-M-P-H	Child vs. group	T	Crying baby*
Prof-M-I-L	Shareholders, employees	T	CEO
Prof-A-I-H	Society that values privacy	O	Whistleblower

B. Dilemma generation

The first step in generating novel dilemmas is to specify which types of risk (Threat or Opportunity) needs to be operationalized as a dilemma. This determines the level of the *DilemmaType* dimension. Next, dilemmas can be generated by relying on the taxonomy's structure and asking questions such as: What are the potential situations that a decision-maker may encounter in a work setting (*Context* - **Professional**) which require no direct physical interaction (*PhysicalDistance* - **Impersonal**) with the Risk Owner and would require a choice between decreasing the utility of the Risk Owner while providing benefit for the Strategy Owner (*LevelOfConflict* - **Low**)? A potential answer is illustrated by the CEO dilemma:

You are the CEO of a giant IT company which specializes in the development and production of microprocessors. Based on internal communications you become aware of a major vulnerability in one of your products. If this vulnerability becomes public knowledge, it will have a very negative impact on the share prices, and there is no way to prevent this from becoming public knowledge soon. As you own a large number of the company's stocks and options you would lose a lot of money. Based on your knowledge about the situation you consider selling $24 million worth of your shares and options. Would you sell your stocks of the company you are a leader of before the vulnerability hits the news?

A dilemma which operationalizes an Opportunity Risk can be developed by asking the following question based on the taxonomy's structure, given that *DilemmaType* is set to **Altruistic**: What are the potential situations that a decision-maker may encounter in a work setting (*Context* - **Professional**) which require no direct physical interaction (*PhysicalDistance* - **Impersonal**) with the Risk Owner and would require a choice between increasing the utility of the Risk Owner while causing a significant loss of utility for the Strategy Owner (*LevelOfConflict* - **High**)? A potential answer is illustrated by the Whistleblower dilemma:

You work as an information technology service contractor for various governmental organizations. Your work is strictly confidential and classified, you are legally obliged not to talk about the details of your job to anyone neither privately nor publicly. During your work you realize that the material you are working on reveals the extent and sophistication with which your government monitors digital communications between its citizens. If you reveal these secret documents to the public you will instantly receive huge media attention, charges will be pressed against you for theft of government property and you may have to flee your country to avoid going to prison. Would you reveal the secret governmental documents to the public if you were sure that serious consequences for yourself would be unavoidable?

The questions accompanying the taxonomy narrow down the search-space sufficiently and guide researchers so that dilemmas can be generated by systematically manipulating each level associated with the dimensions. Control over the variables, and systematic manipulation would not be feasible without an explicitly and properly defined structure.

V. EVALUATION OF THE PROPOSED TAXONOMY

A key component of the design science research methodology is the evaluation of the resulting artifact. Despite this key requirement and despite the popularity of taxonomies, there is a lack of consensus on how to evaluate taxonomies according to the literature review provided in [43]. The paper therefore constructs a framework for taxonomy evaluation, which is used in this section for evaluating the proposed taxonomy of situations. Furthermore, several points are considered from the article available at [44].

Based on the framework proposed by [43] it is possible to analyze the evaluation procedure by answering the following three questions: Who was involved in the evaluation (i.e. subject)? What type of objects were used for the evaluation (i.e. object)? How was the evaluation performed (i.e. method)?

Evaluation was performed by two persons, each with different academic backgrounds (i.e. psychology and computer science), one being involved in the development of the taxonomy. Objects used for building the taxonomy (i.e. existing dilemmas) and objects not used (i.e. dilemmas generated from the taxonomy) for taxonomy construction were utilized during the evaluation, therefore the coverage of objects can be characterized as selective, but not exhaustive. The evaluation relies on the logical argument and illustrative scenario methods.

The taxonomy's face validity (i.e. compatibility with existing theories and ability to capture relevant concepts in a field [44]) was assessed subjectively as satisfactory, as it creates a link between well-established research results and various types of risk identified in the CIRA method. However, it should be noted that the particular operationalization of risks proposed in this paper is not the only one conceivable. Logical argument revealed that the taxonomy may suffer from a lack of completeness, so that certain dilemmas may arise that do not fit well in the existing taxonomy. The issue of reciprocal altruism (i.e.

the decision-maker takes a short-term loss, with the expectation that at a later point it will be reciprocated by the other party) arose during logical arguments. Currently the taxonomy does not have a corresponding class. This could be alleviated by the inclusion of an additional **Reciprocal** sub-class for the **Altruistic** *DilemmaType* dimension. While it may be possible that an act of reciprocal altruism is motivated by rational cost-benefit analysis; **Rational** dilemmas by definition have no impact on other stakeholders. Furthermore, by definition **Moral** dilemmas refer to potential losses exerted on others, while **Altruistic** dilemmas refer to choices that increase the benefit of others, therefore the categories fulfill the requirement of mutual exclusivity [44]. The illustrative scenario method was used to demonstrate how existing dilemmas and situations can be classified according to the taxonomy. Furthermore, the method presented how previously non-existent dilemmas can be generated in a systematic and principled way by manipulating the levels associated with each dimension of the taxonomy. Therefore, the usability property has been demonstrated, while more rigorous assessments may be advantageous in the future.

Overall, the taxonomy fulfills the key requirements by enabling the creation of novel dilemmas in a systematic and principled way; by providing a way to operationalize both types of risks identified in the CIRA method; by enabling the classification of existing dilemmas and real-world situations into unique categories.

VI. Discussion

In order to predict stakeholder behavior, it is crucial to obtain information about the individual and the context in which a decision-maker operates from a person-situation interactionist perspective. During the development of the CIRA method, which focuses on human motivation for the purpose of risk analysis, characterization of the decision-maker's motivation received more attention than relevant aspects of the situation. This resembles the state of the scientific literature which is abundant with systematic and well-tested personality and trait theories, whereas the description of situational aspects is less advanced and far from being unified [8].

This work contributes to the development of the CIRA method in the following ways: by developing a taxonomy of situations based on a review of previous approaches; by identifying relevant psychological constructs and establishing a mapping between these and CIRA's key risk-concepts. The selection of situational dimensions included in the taxonomy is supported by empirical evidence and theoretical considerations. The key utility of the proposed taxonomy is that it allows the systematic manipulation and control of situational factors, thus enables the principled development of hypothetical scenarios which will be used in future investigations to test and improve the existing framework's predictive capabilities.

Several widely-publicized, high-impact decisions (e.g. diesel emission-scandal [45], bribery [46], Watergate-scandal [47], insider trading [48], etc.) with negative outcomes for various classes of Risk Owners fall in the **"Professional-Moral-Impersonal-Low-conflict"** category according to the proposed taxonomy. While this category was not explicitly defined in previous studies, the potential effect of anxiety (as experienced by the decision-maker when contemplating the consequences of the actions) on choices was investigated in various studies. Researchers have found that both high-anxiety and low-anxiety psychopaths were more likely than participants in a control group to endorse harmful impersonal acts which cause indirect or remote harm to others [49]. Additionally, low-anxiety psychopaths were more likely than control subjects or high-anxiety psychopaths to enact harmful behavior in personal dilemmas. Another study found that the anti-anxiety drug lorazepam caused a dose-dependent increase in participants' willingness to engage in harmful actions in the personal condition (for high-conflict and low-conflict situations as well), but it did not significantly change responses in case of impersonal dilemmas [50]. These results suggest that-since impersonal situations are less anxiety-provoking (compared with personal situations), -detachment from consequences in itself has important implications for moral decision-making for a variety of settings where Strategy Owners and Risk Owners are interconnected (and at the same time separated) by sophisticated technical means. The importance of understanding how human moral judgement is influenced by situational factors becomes increasingly important as more and more autonomous systems will have to rely on some sort of simulated human judgement when making their choices on behalf of others. Due to the fact that several problems in real-life have no objectively defined criteria which could be used to evaluate whether a decision is right or wrong, systems may have to use human judgements as the gold standard [51].

A. Limitations and further work

While the benefits of the proposed taxonomy (i.e. enabling systematic development of dilemmas, and classification of situations) have been demonstrated through the examples, there are limitations which have to be considered. Empirical tests are needed to assess whether the taxonomy allows useful deductions regarding the predictability of subjects' choices. If the taxonomy successfully captures the decision-makers' mental model, systematic differences may emerge from the responses, thus valid predictions on probable subject behavior could be made simply by matching the leaf-nodes in the taxonomy with real-world situations. This empirical test represents planned future work. The taxonomy is constructed theoretically and by considering previous research results, thus enumerates dimensions and specifies the associated levels on each dimension. This method may result in leaf-nodes that are rare or non-existent in realistic settings, and quickly leads to a combinatorial explosion as the number of dimensions increases, making it unmanageable for human experts. However, the inclusion of additional dimensions may be necessary to capture other forms of dilemmas that may arise in realistic settings. Inclusion of the *AmountOfBenefitProvided* dimension in case of **Altruistic** dilemmas would enable manipulation of

the amount of benefit provided by an action, which could also be an important factor from the decision-maker's perspective. Furthermore, incorporating a *Reciprocal* sub-dimension for **Altruistic dilemmas** would potentially improve the taxonomy's capability to classify actions with hidden motives. The overall appropriateness of included dimensions should be judged by considering the purpose of the application and the existing domain-specific research results.

The proposed taxonomy has been evaluated using various methods, however more rigorous evaluations may be carried out in the future by applying the taxonomy in a real-world context using the action research method (i.e. asking practitioners/researchers to generate dilemmas using the taxonomy) or using the case study method over an extended period of time, for real-world applications to evaluate its performance more independently [43].

During dilemma development care must be taken to control for several undesirable effects that may threaten the validity of the measure (e.g framing effects; descriptions suggestive of the trade-offs assumed implicitly by the researcher; and to avoid lengthy dilemmas resulting in respondent fatigue [52]). Furthermore, it is especially challenging to control for spill-over effects across contexts (i.e. a choice in a professional setting may have important implications for the private context as well). Finally, it should be mentioned that it is possible to construct the same scenario both as an **Altruistic** dilemma (i.e. providing benefit for others at own expense) and as a **Moral** dilemma (i.e. decreasing the utility of others) by manipulating the *Risk Owner* variable (e.g. Whistleblower-dilemma can be turned into a special kind of **Moral** dilemma -in which both stakeholders would have to take a loss- when the previously identified *Risk Owner* is replaced by the employer who will be negatively impacted). For real-world applications which aim at simulating the Strategy Owner's mental model of the situation, it would be crucial to understand which framing is more active from the set of potential mental representations. The decision-maker's value hierarchy obtained through unobtrusive measures [53], [54] may enable inferences about which cognitive representation is more active (i.e. how does the *Strategy Owner* actually perceive the situation?). The topic requires extensive future work and needs to be guided by relevant results obtained from investigations into how values get activated, how they motivate behavior, and how they relate to pro-social and moral decision-making, since the hierarchy of values fundamentally influences how a situation is perceived by individuals [55].

Taken together, these observations lead to the conclusion that challenging dilemmas are not just hard to solve but are hard to develop as well. Furthermore, real-world applications need to combine several research results in order to predict individual choices in specific situations, where complex interactions between personal, intrapersonal and situational factors produce observable outcomes.

VII. Conclusions

This paper aimed at proposing and developing a taxonomy of situations, based on existing literature and theoretical considerations by identifying limitations in existing solutions and by extending on well-established research results. The need for the development of a domain-specific taxonomy of situations arises from the fact that predicting the choices of key decision-makers is a central aim of the CIRA method. While personality and trait theories are suitable for characterizing individuals, they cannot account for the intra-individual personality-state variability expressed in various situations and across different social roles. The taxonomy of situations proposed in this work incorporates key situational attributes which have significant influence on decision-makers, as demonstrated by existing research results. The taxonomy proposes a novel way to operationalize risks identified in the CIRA method, thus providing a connection between separate areas of scientific inquiry. Additional benefits of the proposed taxonomy include: enabling the creation of novel dilemmas in a systematic and principled way; categorization of existing dilemmas and real-world situations based on their attributes. The dilemmas generated by utilizing the taxonomy's structure enable further empirical assessments and improvements related to CIRA's predictive capabilities. This work contributes to the interdisciplinary effort which aims at developing novel tools for improved decision-making by focusing on human-related risks in the context of information security risk analysis.

Acknowledgements

This work was partially supported by the project IoTSec – Security in IoT for Smart Grids, with number 248113/O70 part of the IKTPLUSS program funded by the Norwegian Research Council.

References

[1] N. Frederiksen, "Toward a taxonomy of situations," *American Psychologist*, vol. 27, no. 2, p. 114, 1972.

[2] L. Rajbhandari and E. Snekkenes, "Using the conflicting incentives risk analysis method," in *IFIP International Information Security Conference*, pp. 315–329, Springer, 2013.

[3] E. Snekkenes, "Position paper: Privacy risk analysis is about understanding conflicting incentives," in *IFIP Working Conference on Policies and Research in Identity Management*, pp. 100–103, Springer, 2013.

[4] P. E. Meehl, *Clinical versus statistical prediction: A theoretical analysis and a review of the evidence.* University of Minnesota Press, 1954.

[5] W. M. Grove, D. H. Zald, B. S. Lebow, B. E. Snitz, and C. Nelson, "Clinical versus mechanical prediction: a meta-analysis.," *Psychological assessment*, vol. 12, no. 1, p. 19, 2000.

[6] P. M. Spengler, "Clinical versus mechanical prediction," *Handbook of Psychology, Second Edition*, vol. 10, 2012.

[7] S. B. Sells, "An interactionist looks at the environment.," *American Psychologist*, vol. 18, no. 11, p. 696, 1963.

[8] M. A. Ten Berge and B. De Raad, "Taxonomies of situations from a trait psychological perspective. a review," *European Journal of Personality*, vol. 13, no. 5, pp. 337–360, 1999.

[9] B. S. Bloom *et al.*, "Taxonomy of educational objectives. vol. 1: Cognitive domain," *New York: McKay*, pp. 20–24, 1956.

[10] L. R. Goldberg, "An alternative description of personality: the big-five factor structure.," *Journal of personality and social psychology*, vol. 59, no. 6, p. 1216, 1990.

[11] N. Prat, I. Comyn-Wattiau, and J. Akoka, "A taxonomy of evaluation methods for information systems artifacts," *Journal of Management Information Systems*, vol. 32, no. 3, pp. 229–267, 2015.

[12] N. A. Noureldien, "A novel taxonomy of manet attacks," in *2015 International Conference on Electrical and Information Technologies (ICEIT)*, pp. 109–113, IEEE, 2015.

[13] A. Fahad, N. Alshatri, Z. Tari, A. Alamri, I. Khalil, A. Y. Zomaya, S. Foufou, and A. Bouras, "A survey of clustering algorithms for big data: Taxonomy and empirical analysis," *IEEE transactions on emerging topics in computing*, vol. 2, no. 3, pp. 267–279, 2014.

[14] H. Debar, M. Dacier, and A. Wespi, "A revised taxonomy for intrusion-detection systems," in *Annales des télécommunications*, vol. 55, pp. 361–378, Springer, 2000.

[15] D. J. Solove, "A taxonomy of privacy," *University of Pennsylvania law review*, vol. 154, p. 477, 2005.

[16] M. S. Krause, "Use of social situations for research purposes.," *American Psychologist*, vol. 25, no. 8, p. 748, 1970.

[17] H. H. Kelley, J. G. Holmes, N. L. Kerr, H. T. Reis, C. E. Rusbult, and P. A. Van Lange, *An atlas of interpersonal situations*. Cambridge University Press, 2003.

[18] G. A. Marlatt, "Taxonomy of high-risk situations for alcohol relapse: evolution and development of a cognitive-behavioral model," *Addiction*, vol. 91, no. 12s1, pp. 37–50, 1996.

[19] L. A. Pervin, "A free-response description approach to the analysis of person-situation interaction," in *The Psychology of Social Situations*, pp. 40–55, Elsevier, 1981.

[20] G. L. Van Heck, "The construction of a general taxonomy of situations," *Personality psychology in Europe: Theoretical and empirical developments*, vol. 1, pp. 149–164, 1984.

[21] M. T. Berge and B. D. Raad, "The construction of a joint taxonomy of traits and situations," *European Journal of Personality*, vol. 15, no. 4, pp. 253–276, 2001.

[22] Y. Yang, S. J. Read, and L. C. Miller, "A taxonomy of situations from chinese idioms," *Journal of Research in Personality*, vol. 40, no. 5, pp. 750–778, 2006.

[23] D. Funder, E. Guillaume, S. Kumagai, S. Kawamoto, and T. Sato, "The person-situation debate and the assessment of situations," *The Japanese Journal of Personality*, vol. 21, no. 1, pp. 1–11, 2012.

[24] S. Parrigon, S. E. Woo, L. Tay, and T. Wang, "Caption-ing the situation: A lexically-derived taxonomy of psychological situation characteristics.," *Journal of Personality and Social Psychology*, vol. 112, no. 4, p. 642, 2017.

[25] N. S. Endler, J. Hunt, and A. J. Rosenstein, "An sr inventory of anxiousness.," *Psychological Monographs: General and Applied*, vol. 76, no. 17, p. 1, 1962.

[26] D. Magnusson, "An analysis of situational dimensions," *Perceptual and motor skills*, vol. 32, no. 3, pp. 851–867, 1971.

[27] N. Frederiksen, O. Jensen, A. E. Beaton, and B. Bloxom, *Prediction of organizational behavior.* Pergamon, 1972.

[28] R. H. Moos, "Conceptualizations of human environments.," *American psychologist*, vol. 28, no. 8, p. 652, 1973.

[29] R. H. Price, "The taxonomic classification of behaviors and situations and the problem of behavior-environment congruence," *Human Relations*, vol. 27, no. 6, pp. 567–585, 1974.

[30] J. P. Forgas, "The perception of social episodes: Categorical and dimensional representations in two different social milieus," in *The Psychology of Social Situations*, pp. 80–94, Elsevier, 1981.

[31] CollinsDictionary, "Taxonomy definition and meaning." Web: https://www.collinsdictionary.com/dictionary/english/taxonomy.

[32] J. D. Greene, R. B. Sommerville, L. E. Nystrom, J. M. Darley, and J. D. Cohen, "An fmri investigation of emotional engagement in moral judgment," *Science*, vol. 293, no. 5537, pp. 2105–2108, 2001.

[33] J. D. Greene, S. A. Morelli, K. Lowenberg, L. E. Nystrom, and J. D. Cohen, "Cognitive load selectively interferes with utilitarian moral judgment," *Cognition*, vol. 107, no. 3, pp. 1144–1154, 2008.

[34] F. Cushman and J. D. Greene, "Finding faults: How moral dilemmas illuminate cognitive structure," *Social neuroscience*, vol. 7, no. 3, pp. 269–279, 2012.

[35] J. P. Rushton, R. D. Chrisjohn, and G. C. Fekken, "The altruistic personality and the self-report altruism scale," *Personality and individual differences*, vol. 2, no. 4, pp. 293–302, 1981.

[36] D. Heller, J. Komar, and W. B. Lee, "The dynamics of personality states, goals, and well-being," *Personality and Social Psychology Bulletin*, vol. 33, no. 6, pp. 898–910, 2007.

[37] K. M. Sheldon, R. M. Ryan, L. J. Rawsthorne, and B. Ilardi, "Trait self and true self: Cross-role variation in the big-five personality traits and its relations with psychological authenticity and subjective well-being.," *Journal of personality and social psychology*, vol. 73, no. 6, p. 1380, 1997.

[38] D. Querstret and O. C. Robinson, "Person, persona, and personality modification: An in-depth qualitative exploration of quantitative findings," *Qualitative Research in Psychology*, vol. 10, no. 2, pp. 140–159, 2013.

[39] D. Heller, W. Q. E. Perunovic, and D. Reichman, "The future of person-situation integration in the interface between traits and goals: A bottom-up framework," *Journal of Research in Personality*, vol. 43, no. 2, pp. 171–178, 2009.

[40] B. W. Roberts and E. M. Donahue, "One personality, multiple selves: Integrating personality and social roles," *Journal of Personality*, vol. 62, no. 2, pp. 199–218, 1994.

[41] D. Wood and B. W. Roberts, "Cross-sectional and longitudinal tests of the personality and role identity structural model (prism)," *Journal of Personality*, vol. 74, no. 3, pp. 779–810, 2006.

[42] C. Prendergast, "The provision of incentives in firms," *Journal of economic literature*, vol. 37, no. 1, pp. 7–63, 1999.

[43] D. Szopinski, T. Schoormann, and D. Kundisch, "Because your taxonomy is worth IT: towards a framework for taxonomy evaluation," in *27th European Conference on Information Systems - Information Systems for a Sharing Society, ECIS 2019, Stockholm and Uppsala, Sweden, June 8-14, 2019*, 2019.

[44] S. Shorrock, "Twelve properties of effective classification schemes." Web: https://humanisticsystems.com/2018/08/31/twelve-properties-of-effective-classification-schemes/.

[45] R. Hotten, "Volkswagen: The scandal explained." Web: https://www.bbc.com/news/business-34324772.

[46] B. Venard, "Lessons from the massive siemens corruption scandal one decade later." Web: http://theconversation.com/lessons-from-the-massive-siemens-corruption-scandal-one-decade-later-108694.

[47] Wikipedia, "Watergate scandal." Web: https://en.wikipedia.org/wiki/Watergate_scandal.

[48] S. Gallgaher, "Intel ceo sold all the stock he could after intel learned of security bug." Web: https://arstechnica.com/information-technology/2018/01/intel-ceos-sale-of-stock-just-before-security-bug-reveal-raises-questions/.

[49] M. Koenigs, M. Kruepke, J. Zeier, and J. P. Newman, "Utilitarian moral judgment in psychopathy," *Social cognitive and affective neuroscience*, vol. 7, no. 6, pp. 708–714, 2011.

[50] A. M. Perkins, A. M. Leonard, K. Weaver, J. A. Dalton, M. A. Mehta, V. Kumari, S. C. Williams, and U. Ettinger, "A dose of ruthlessness: Interpersonal moral judgment is hardened by the anti-anxiety drug lorazepam.," *Journal of Experimental Psychology: General*, vol. 142, no. 3, p. 612, 2013.

[51] J.-F. Bonnefon, A. Shariff, and I. Rahwan, "The social dilemma of

autonomous vehicles," *Science*, vol. 352, no. 6293, pp. 1573–1576, 2016.

[52] J. F. Christensen, A. Flexas, M. Calabrese, N. K. Gut, and A. Gomila, "Moral judgment reloaded: a moral dilemma validation study," *Frontiers in psychology*, vol. 5, p. 607, 2014.

[53] A. Szekeres, P. S. Wasnik, and E. A. Snekkenes, "Using demographic features for the prediction of basic human values underlying stakeholder motivation," in *Proceedings of the 21st International Conference on Enterprise Information Systems - Volume 2: ICEIS,*, pp. 377–389, INSTICC, SciTePress, 2019.

[54] A. Szekeres and E. A. Snekkenes, "Unobtrusive psychological profiling for risk analysis," in *Proceedings of the 15th International Joint Conference on e-Business and Telecommunications - Volume 1: SECRYPT,*, pp. 210–220, INSTICC, SciTePress, 2018.

[55] S. H. Schwartz, "Basic values: How they motivate and inhibit prosocial behavior," in *Prosocial motives, emotions, and behavior: The better angels of our nature* (M. E. Mikulincer and P. R. Shaver, eds.), pp. 221–241, American Psychological Association, 2010.