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## **How abstract is risk for workers? Expertise, context and introspection in abstract concepts**

Anna M. Borghi\*<sup>◦</sup>, Nicoletta Caramelli, Annalisa Setti<sup>^</sup>§

\* Department of Psychology, University of Bologna, Italy

◦ Institute of Science and Technologies of Cognition, CNR, Rome, Italy

<sup>^</sup> Trinity College Institute of Neuroscience, TCD, Ireland

§ University College Cork, Ireland

Correspondence:

Anna M. Borghi

Dipartimento di Psicologia,

University of Bologna,

Viale Berti-Pichat, 5,

40127 Bologna

Italia

Tel: +39 0512091838

Fax: +39 051243086

Email: [anna.borghi@gmail.com](mailto:anna.borghi@gmail.com)

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### **ABSTRACT**

Two studies were performed to test whether abstract concepts are grounded in experience and activate introspective/linguistic information. In Study 1, four groups of participants, each with different expertise in the domain of safety and security at the workplace (S&S), defined abstract concepts belonging to the S&S domain and differing in degree of abstractness. The definitions included mainly situations, confirming grounding of abstract concepts. In Study 2 the task was performed by students with no experience of S&S. The definitions were modulated by participants' expertise; the role of introspection increased with more abstract concepts. Results support embodied theories on abstract concepts.

**Keywords:** abstract concepts; expertise; categorization; introspection; context; situations; grounded cognition; embodied cognition.

How abstract is risk for workers?  
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Introduction

For many years the study of abstract concepts, as “freedom” and “justice”, has been almost completely overlooked in research on conceptual knowledge. However, abstraction represents one of the most sophisticated capabilities of our species. Providing an explanation of abstract concepts is therefore important, and it is even crucial for theories of embodied and grounded cognition (Barsalou, 2008; Borghi & Caruana, 2015). It is namely much easier for an embodied view to explain the representation of concepts as “table”, the referent of which is an easily perceivable object, than of abstract concepts such as “friendship” and “cause”. Importantly, concrete and abstract concepts are not dichotomously opposed; they are rather distributed along a continuum ranging from very concrete to very abstract concepts.

The great variability of abstract concepts renders it quite difficult to find a theoretical framework that accounts for them all. In recent years different approaches inspired by embodied and grounded (EG) cognition have sought to explain how abstract concepts are represented (for reviews see Borghi & Binkofski, 2014; Borghi et al., under review; Pecher et al., 2011). All these approaches share the view that abstract concepts arise from simulation processes: in order to understand and correctly use them, one needs to form a simulation recruiting the same sensorimotor system involved while experiencing their referent. The first and more influential one is based on metaphors (e.g., Lakoff & Johnson, 1980) and is supported by evidence showing that abstract concepts are represented in terms of concrete concepts. For example, the abstract concept of time is based on that of space (e.g., Casasanto & Boroditsky, 2008; Boroditsky & Ramscar, 2002), and abstract notions such as God and Evil are linked to vertical metaphors (Meier et al., 2007). A second approach relates abstract words to actions. So, for example, judging the sensibility of sentences describing the transfer of concrete objects or abstract information requires less time when the action implied by the sentence matches the action required to make the response (action–sentence compatibility effect, or ACE, Glenberg et al., 2008). According to a further recent view, emotions play a major role for abstract concepts representation (AEA, Affective embodiment account: Kousta et al., 2011; Vigliocco et al. 2014). According to the situational and introspective view (Barsalou, 1999; Barsalou & Wiemer-Hastings, 2005), while both concrete and abstract concepts are grounded in situations, situations can be even more crucial for abstract concepts. Abstract concepts are associated with a wider variety of situations than concrete concepts, and, while concrete concepts attention focuses primarily on objects with background situations, abstract concepts lead to focusing attention primarily on events, on social aspects, and on introspective aspects of situations. For example, the concept ‘consequence’ is related to situations involving a preceding event and introspective processes (see Barsalou & Wiemer-Hastings, 2005; Setti & Caramelli, 2005; Wiemer-Hastings et al., 2001; Wiemer-Hastings & Xu, 2005; Wiemer-Hastings & Graesser, 2000). Adopting this approach has the advantage to account for the variety of abstract concepts and to explain why, for example, the concept ‘principle’ is evaluated as more abstract than ‘idea’. Situations can vary in the constraints they exert on concepts, so that the less and the more abstract the situational constraints (e.g. causal, temporal, and spatial) are, the more abstract a concept is.

In our view the most important novelty in the last years is the emergence of multiple representation approaches, according to which not only sensorimotor but also linguistic experience plays a role in shaping abstract concepts representation (Dove, 2011, 2014; Borghi & Binkofski, 2014). We will here focus on the WAT (Words As social Tools) view

(Borghgi & Cimatti, 2009; Borghgi & Binkofski, 2014) which proposes that both sensorimotor and linguistic experience concur in representing abstract and concrete concepts, but that they are differently distributed. Since abstract concepts do not refer to concrete and clearly bounded objects but to an heterogeneous variety of situations and states, and since their members are more sparse and diverse than members of concrete categories, language is more critical for their acquisition. Linguistic labels can namely work as a glue helping us to collect such a sparse variety of experiences, and the reactivation of linguistic experience is more crucial for abstract concepts representation than for concrete ones. In support of this hypothesis, behavioral and TMS studies have demonstrated that processing of abstract concepts activates linguistic information and involves the mouth effector in absence of explicit speech (e.g., Borghgi et al., 2011; Ghio et al., 2013; Gleitman et al., 2005; Granito et al., 2015; Scorolli et al., 2011; 2012; Wauters et al., 2003) and fMRI studies have shown clear involvement of areas related to language production and comprehension during abstract concepts processing, as the left inferior frontal gyrus and the left middle temporal gyrus (Binder et al., 2009; Hoffman et al., 2015; Sakreida et al., 2013; Wang et al., 2010). According to WAT, the involvement of language and of the mouth is due either to the activation of the linguistically mediated acquisition experience, or to the use of a form of inner language helping to re-explain to oneself the meaning of the word, or to both processes (Borghgi & Binkofski, 2014).

In this theoretical framework, this study aims to investigate whether abstract concepts are grounded in experiences, i.e. whether they evoke specific contexts and are modulated by participants' expertise, and whether they evoke also linguistic/introspective elements.

A specific abstract domain, that of safety and security (S&S) at the workplace, was selected. Four groups of participants with different working experience in this domain - managers, security-technicians, trade union delegates, and factory workers - were asked to define three abstract concepts belonging to the chosen domain, i.e. 'risk', 'danger' and 'prevention'. The choice of focusing on only three concepts, while possibly limiting the generalization of the results to wider sets of abstract concepts, allows us to better explore the effect of expertise on a specific domain, that of S&S at the workplace.

The definitions produced were parsed in order to code the conceptual relations produced. We distinguished situational, introspective, taxonomic, and attributive relations (Study 1). As the 4 groups of participants in Study 1 were directly involved in the specific domain, i.e. S&S at the workplace, in Study 2 we tested lay participants (university students) who would not directly associate the concepts to workplace situations, but to more general everyday situations.

The following hypotheses were advanced:

- 1) Grounding of abstract concepts in situations. We hypothesize that abstract concepts are grounded in sensorimotor systems and in experiences, similarly to concrete objects. Since abstract concepts do not have concrete and bounded objects as referents, we predict that the definitions provided by the four groups of professionals (managers, security-technicians, trade union delegates, and workers) yield situational information more than any other type of information.

- 2) Effects of expertise. If abstract concepts are grounded in experience, then the effect of expertise, well documented in concrete items, should also be found in abstract concepts. Medin et al. (1997) have shown that taxonomists, landscape workers, and park maintenance personnel categorize concrete items such as trees differently, as their expertise derives from focusing on different aspects of trees. To our knowledge the only attempt to study how expertise modulates abstract concepts was accomplished by Roversi et al. (2013) who showed with a feature production task that students, law graduate and law professionals

differently conceptualize law concepts. However, the results on expertise of this study were preliminary, and pertained only the law domain. In the present study we intend to test whether people with different expertise differently organize their knowledge of a specific domain. If abstract concepts are grounded in experience, we predict that situational components characterize abstract conceptual knowledge of all groups. Beside this, we expect that the definitions provided by the four groups of participants differ with regard to the other components: specifically, we predict that introspective components characterize conceptual organization of workers and delegates, who have a direct “embodied” experience of the S&S domain, while taxonomic components should be more relevant for managers and technicians, who have a declarative knowledge of the domain. We expect students to show mainly, but not only, declarative knowledge because this kind of knowledge meets the requirements for academic performance they are used to.

3) Introspective components. If abstract concepts have a graded structure, then, the definitions of more abstract concepts should rest more on abstract contextual constraints. In particular, we predict that more abstract concepts elicit primarily abstract components, such as the introspective ones (Wiemer-Hastings & Xu, 2005), likely produced through some forms of inner talk, aimed at explaining to oneself the meaning of the concept (Borghi & Binkofski, 2014). Less abstract concepts should instead primarily activate more concrete contextual components, such as situations, locations, agents’ characteristics, relations between entities, and temporal sequences.

To test these hypotheses, an oral definition task was chosen, in which participants were asked to define the three abstract concepts ‘risk’, ‘danger’ and ‘prevention’ belonging to the domain of S&S.

## Study 1 Method

### *Participants*

The participants were 4 groups of 20 experts each. Each group was characterized by a specific type of expertise in the domain of ‘S&S’ at workplace. They were:

- managers, who had very good formal, i.e. theoretical knowledge of the domain but no direct experience;
- security-technicians, who had good domain knowledge on both theoretical and direct experience grounds;
- trade union delegates, who were trained specifically on S&S in a mechanical industry working place;
- workers, who had no theoretical knowledge of the domain, but daily direct experience of possible conditions endangering S&S.

### *Materials*

The materials consisted of the three abstract concepts ‘risk’, ‘danger’, and ‘prevention’. These concepts were selected because they are of paramount relevance in the specific domain of S&S at workplace as well as in many domains in everyday life and, consequently, they are very familiar not only to the four chosen professional groups, but to non-professionals as well.

A preliminary study was performed to assess whether the three chosen nouns differed in their abstractness degree. Following Wiemer-Hastings et al. (2001), the degree of abstractness of concepts depends on the constraints of the situation in which they occur. Due to its prescriptive character, the concept ‘prevention’ should refer to well identified and detailed procedures that can be realized in specific and well-defined locations at workplaces. Instead, due to their generic denotation, both ‘risk’ and ‘danger’ can be supposed to refer to possible situations the realization of which depends on future events. Thus, the concept ‘prevention’ was expected to be less abstract than both ‘risk’ and ‘danger’.

### *Pre-test on materials*

In order to pre-test the material, 12 filler concepts (3 artifacts, 3 natural kinds, 3 emotion concepts, and 3 temporal concepts) were added to ‘risk’, ‘danger’ and ‘prevention’.

An independent sample of 40 students at the University of Bologna was presented with the set of the 15 concepts thus obtained written on a sheet of paper in random order. They were asked to rate the abstractness degree of each concept on a 7 points scale (1 meaning extremely concrete concept and 7 extremely abstract concept).

The ANOVA performed on the abstractness ratings with ‘risk’, ‘danger’, and ‘prevention’ as the independent variable showed a significant difference between the concepts ( $F(2,78) = 7.21$ ,  $MSe = 1.61$ ,  $p < .01$ ) due to ‘prevention’ ( $M = 3.9$ ) being rated as significantly (post-hoc test Newman-Keuls,  $p < .01$ ) more concrete than both ‘risk’ ( $M = 4.7$ ) and ‘danger’ ( $M = 4.9$ ), which did not differ from each other. The reason why the abstractness value is not so far from the midpoint of the scale is due to the fact that the 3 terms were included in a larger set of concepts, ranging from very concrete to very abstract ones, and to the fact that one participant used the value 1 for all the three considered concepts. In sum we predict an effect of expertise that will differentiate the groups on the kind of components produced. Based on the abstractness ratings we also expect that the definitions of both the concepts ‘risk’ and ‘danger’ should rest on introspective components, which characterize high abstractness degree concepts, more than those of the lower abstractness-degree concept ‘prevention’.

### *Procedure*

Each participant was interviewed individually for about 30 minutes by a researcher on the topic of safety and security at workplaces for a general survey on their opinions. At the beginning of the session, each participant was asked: "How would you define ‘X’?" for each of the three concepts (‘risk’, ‘danger’, and ‘prevention’). The definitions, as well as the subsequent interviews, which are not analysed in this study, were tape-recorded. The three definitions provided at the beginning of the interview were transcribed and coded for data analysis in this study.

## Results

### *Coding*

Once transcribed, the definitions were parsed into components to be coded separately. The parsing criteria used were the following (see Borghi & Barsalou, 2001):

a) nouns and modifiers were coded separately only when the modifier directly referred to the concept (e.g., ‘full of’ was coded independently of its noun ‘danger’). Otherwise, they were coded together (e.g., ‘dirty factory’);

b) verbs and their arguments were coded separately (e.g., ‘wear’ was coded independently of its argument ‘helmet’). They were coded together only when the argument had a default value (e.g., ‘in order to prevent something’, where ‘something’ has a default value).

The components thus obtained were distinguished into four types:

1. Situational components that included: space (physical and situation settings, e.g., ‘in the factory’, ‘at work’); time (e.g., ‘yesterday’); action and instrument (e.g., ‘in order to press’, ‘with a hammer’);

2. Introspective components (Wu & Barsalou, 2009) that included: ego involvement (e.g., ‘it happened to me’); emotions (e.g., ‘I am scared when...’); intentional states (e.g., ‘I believe that...’); cognitive processes (e.g., ‘it requires attention’);

3. Taxonomic components that included: superordinate (e.g., ‘risk’ – ‘an unsafe situation’); coordinate, i.e. synonyms and exemplifications, (e.g., ‘risk’ – ‘danger’); and subordinate (e.g., ‘risk’ - ‘fire’) components;

4. Attributive components that included mainly evaluations (e.g., ‘prevention is good’).

Two researchers independently coded the definitions produced by the four groups of participants. The degree of agreement between them was 95.4%. Cases of disagreement were solved after brief discussion.

We performed two analyses one on the whole set of definitions produced by all participants and the other on the definitions obtained from the four groups of participants. The first analysis assessed which components were elicited by each concept, i.e. whether the 3 abstract concepts considered were grounded in situations and what components characterized them depending on their abstractness. The second analysis assessed the effect of expertise by contrasting the definitions obtained from the four groups of participants

Chi square analyses and Correspondence Analyses were performed on the data. Correspondence Analyses were performed when there comprised at least six groups of frequencies, three for each group of variables, necessary to define the coordinates of the points on the graph. In Correspondence Analysis, based on the Chi square test, the frequencies of the relations produced give rise to a broad data matrix allowing for the identification of their weight and their graphical representation as points in a multidimensional space. On the graph, the geometrical proximity of the points shows the degree of their association and the similarity of their distribution (Greenacre & Blasius, 1994). The first dimension explains a Total Inertia higher than that explained by the further dimensions. The maximum number of dimensions is the minimum between the number of columns minus 1 and the number of rows minus 1.

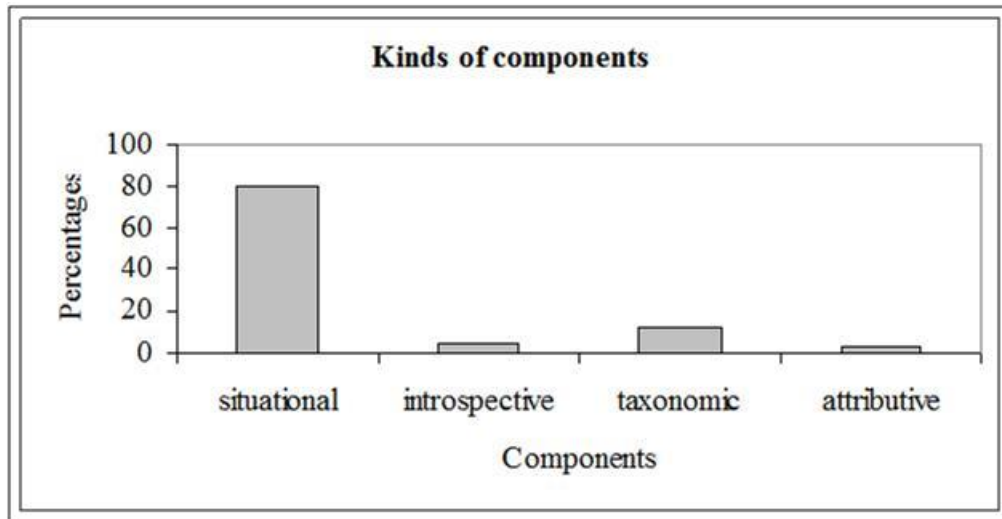
In this study Correspondence Analysis helped in highlighting whether, and if so which, specific components characterized each concept. The first dimension was always discussed because it explained most of the variance, while the second one was discussed only when it explained more than 10% of the variance (for use of Correspondence Analysis in a similar production task see Roversi et al., 2013).

Finally, in order to compare the results of Study 1 to those obtained in Study 2, a log-linear analysis was performed on the frequencies of the components produced by participants in the two Studies.

*Analysis on the components of the whole set of definitions*

As hypothesized, the situational components were the most frequently produced amounting to 80% of the total number of the components produced. The production of taxonomic, introspective and attributive components amounted respectively to 12%, 5%, and 3% (Fig. 1.).

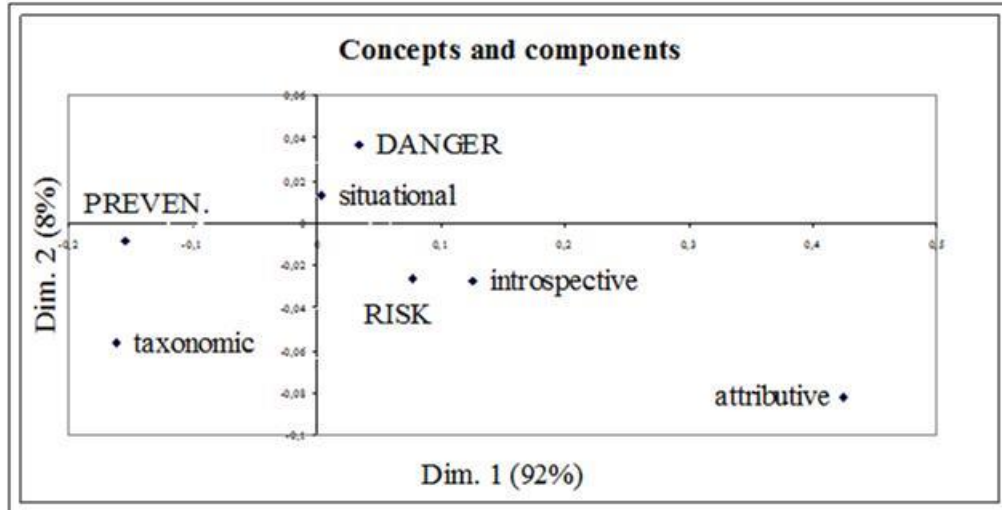
Fig. 1. Total production percentages for each component (Study 1).



These results clearly showed that, in defining abstract concepts, participants mainly activated situational components. Thus, the first hypothesis was verified.

In order to further assess whether, and if so how, the concepts 'prevention', 'risk' and 'danger' were characterized by different types of components, a Correspondence Analysis was performed. This analysis allowed the assessment of the specific components that distinguished the three concepts. The factors of the Correspondence Analysis were the three abstract concepts and the types of the components elicited (Fig. 2.).

Fig. 2. Correspondence analysis with the 3 S&S domain abstract concepts and their definitional components as factors (Study 1).



On the first dimension, explaining 92% of the total variance, the concept 'prevention' that yielded definitions based on taxonomic components, i.e. coordinates, differed from both 'risk' and 'danger' that yielded definitions based on both introspective and attributive components. As the second dimension explained only 8% of the variance, we do not discuss it. The situational components, which were the most frequently produced, had no weight in this analysis as they characterized the definitions of the three concepts equally well.

These results suggest that, while all concepts yielded definitions based on situations, the three concepts differed in the remaining components. The definition of 'prevention', which was rated as less abstract than both 'risk' and 'danger', was characterized by taxonomic components, given by examples, i.e. instructions to be given in situations where

‘prevention’ usually occurs. Instead, the definitions of ‘risk’ and ‘danger’, which were rated as more abstract than ‘prevention’, were characterized by both introspective and attributive components, e.g. ‘scary’, that refer to abstract, unobservable elements of the situations.

*Analysis on the definitions produced by each group of experts*

Overall, the definitions produced by the four groups of professionals differed with regard to the number of components: 32% of the components were produced by workers; 28% by security-technicians, 21% by managers and 19% by delegates. This means that, due to their direct experience of the situations in which the three concepts occur, workers and security-technicians’ definitions were richer than those provided by managers and delegates whose knowledge of the concepts is less linked to direct experiences.

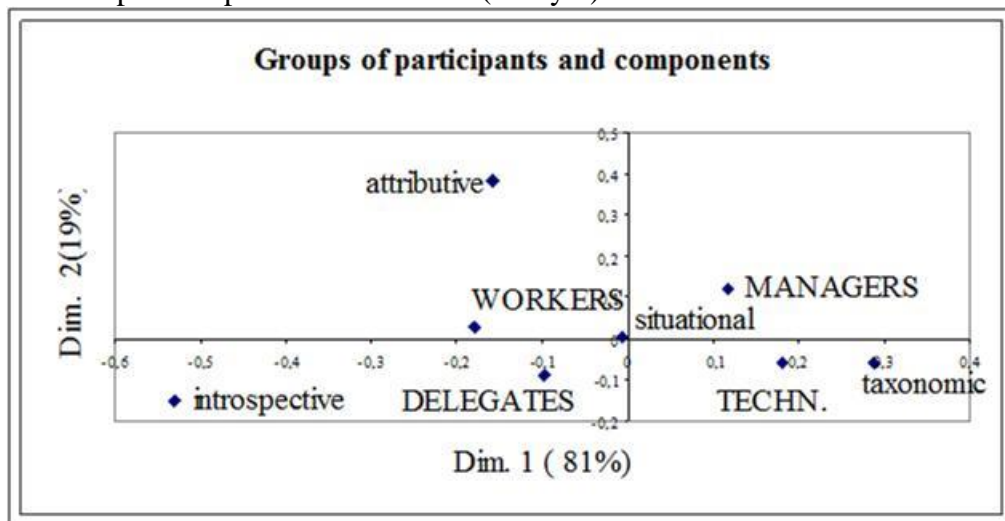
The frequencies of the different components elicited by the three concepts were analyzed in the definitions provided by each of the four groups of professionals’. Across the four groups, situational components were produced more frequently than taxonomic ones that were the second most frequently produced components (see Table 1).

Table 1. Percentage of the types of components produced by each group of professionals.

	Workers	Managers	Technicians	Delegates
situational comp.	81	80	80	79
taxonomic comp.	8	14	17	11
introspect. comp.	7	2	2	7
attrib. comp.	4	4	1	2

In order to assess whether the four groups differed in the components used depending on their specific expertise, a Correspondence Analysis was performed with the four groups of participants and the types of the components produced as factors (Fig 3.).

Fig. 3. Correspondence analysis with the 4 groups of participants and the types of the definitional components produced as factors (Study 1).



On the first dimension, explaining 81% of the variance, workers’ definitions, characterized by introspective components, differed from those produced by both managers and security-technicians which were characterized by taxonomic components. On the second dimension, explaining 19% of the variance, managers’ definitions, characterized by attributive components, differed from those produced by delegates, which were characterized



by introspective components (situational components had no weight in this analysis as they characterized the definitions produced by the four groups of experts equally well).

In order to better understand the role of expertise in producing definitions in the S&S domain, we analyzed the definitions at a more fine grained level by combining the three concepts and analysis each kind of component separately. Therefore we conducted four Correspondence Analysis, one for each component (Situational, Introspective, Taxonomic and Properties) with factors the four groups of experts and, in turn, the subcomponents of each kind of component. For example for the Correspondence Analysis on the Taxonomic components we considered group of experts: managers, security technicians, delegates and workers, and the three subcomponents: superordinate, subordinate and coordinate components. For situational components managers' definitions were characterized by situations and process, while workers' ones were characterized by actions and instrument (dim 1, 60% of the variance), security technicians' definitions referred to patients and space (dim 2, 26% of the variance) as opposed to managers' definitions which referred to causes. As to introspective components managers' definitions were characterized by cognitive processes (dim 1, 57% of the variance), while security technicians definitions were characterized by emotions, evaluations and self-involvement; (dim 2, 27% of the variance) delegates' definitions were characterized by emotions and evaluation, while security technicians' definitions were characterized by representations. For taxonomic components, workers' definitions were characterized by subordinates, while security technicians' definitions were characterized by coordinates (dim 1, 91% of the variance); managers' definitions were characterized by superordinate concepts, as opposed to coordinate concepts for delegates (dim 2, 9% of the variance). For properties, workers' definitions were characterized by perceptual properties, while managers' definitions were characterized by qualities (one dimension).

### Discussion

Our results confirm the three predictions advanced.

As expected, the selected abstract concepts elicited definitions characterized by situations. This confirms that abstract concepts, since they do not have objects as referents, are grounded in situations.

While situations were produced by all groups, the different types of expertise in the S&S domain influenced the production of the other components. The definitions of workers and delegates, who directly experience risky and dangerous situations and prevention conditions in their daily lives, were characterized by introspective elements. Managers and security-technicians, who have mostly a declarative knowledge of the aforementioned situations, grounded their definitions not only on situational, but also on taxonomic and, to a lesser extent, attributive components, i.e. evaluations. Within taxonomic relations, workers produced more detailed components (subordinate elements), while the level of abstraction increased in security technicians and even more in managers (from coordinate to superordinate elements).

The results also showed that, the higher the abstractness degree of the concept, the more abstract were the activated components. In fact, the more abstract concept-nouns 'risk' and 'danger' were characterized mainly by introspective and attributive information, i.e. personal involvement and evaluations, which characterize the more abstract situational constraints (Wiemer-Hastings et al., 2001). The less abstract concept 'prevention' was characterized by taxonomic information, probably due to the fact that this information consisted mainly in examples of how to avoid dangerous situations.

### Study 2

In Study 1, the participants' common involvement in S & S at the workplace could limit the possibility to generalize the results. Collecting participants' definitions at their workplace could have encouraged their focusing only on situations of a specific type, those related to the workplace, whereas the concepts 'prevention', 'risk' and 'danger' refer to a wide variety of domains.

Study 2 was primarily aimed at checking whether the results obtained in Study 1 could be replicated with lay people, who have both declarative and direct knowledge of 'prevention', 'risk' and 'danger' in several different domains such as car-accidents, sports, disease etc. and who are unbiased toward the particular domain of workplace. It is possible to hypothesize that the same concept referred to many domains activates more abstract knowledge than when it is referred to a single, well-defined domain.

We hypothesized that the definitions produced should be again characterized by situational components. We also expected taxonomic components due to the nature of definitions students are used to in their day-to-day academic life. However, we expected the introspective components to characterize concepts' definitions more in this study than in Study 1 due to the variety of contextual settings participants can refer to. The aim of Study 2 was also to assess whether the link between the abstractness degree of the concepts and the production of introspective components could be found with non-professional participants.

## Method

### *Participants*

Nineteen students at the University of Bologna volunteered their participation.

### *Materials*

The same three abstract concepts ('risk', 'danger', and 'prevention') were used as in Study 1.

### *Procedure*

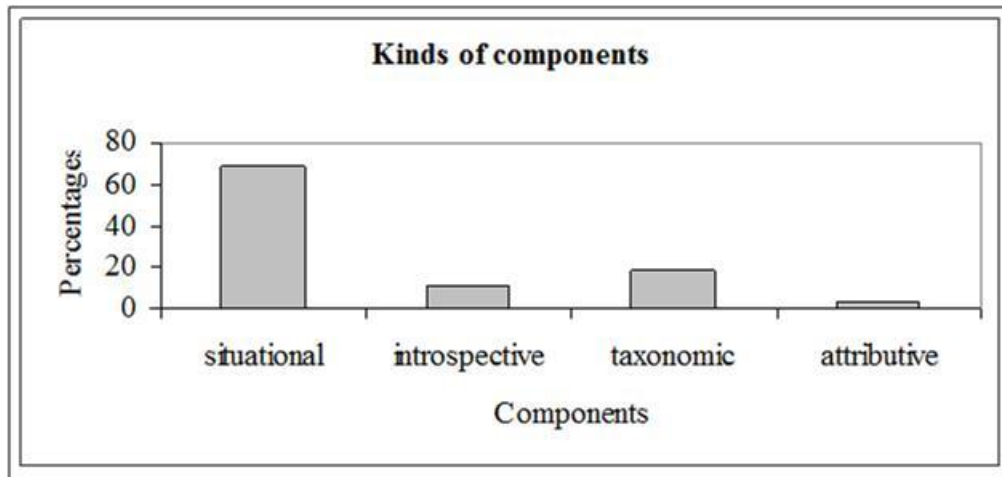
The participants were presented with three sheets of paper in random order, one for each concept. On each sheet, below the printed concept, there were five blank lines where participants had to write their definition of the concept.

### *Results*

Two researchers independently transcribed, parsed and coded the participants' productions with the same criteria as in Study 1. They agreed on 97.6% of the items and the few cases of disagreement were solved after brief discussion.

As predicted by the first hypothesis, the situational components were again the most frequently produced (68%) followed by the taxonomic (18%) and the introspective (11%) components. The attributive components were again very few (3%) (Figure 4.).

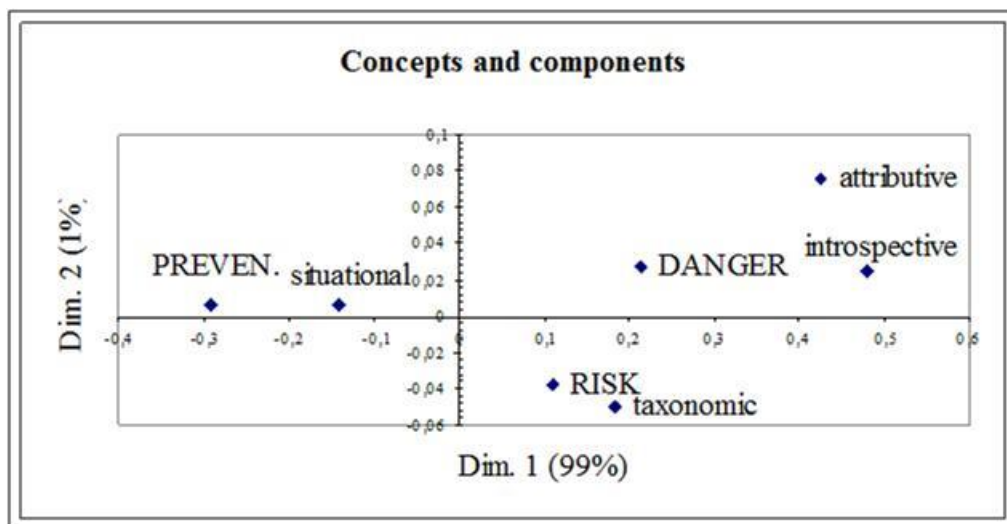
Fig. 4. Total production percentages for each component (Study 2).



Pair-wise comparisons showed a difference between the more abstract concepts ‘danger’ and ‘risk’ eliciting definitions based more on the introspective components than the less abstract concept ‘prevention’ that elicited definitions based more on the situational components [respectively  $\chi^2(1, N=116) = 7.16, p < .007$  and  $\chi^2(1, N=110) = 4.5, p < .03$ ]. Accordingly, the asymmetry between ‘prevention’ and both ‘risk’ and ‘danger’ was replicated. In addition, the introspective components, which refer to more general, abstract contextual settings, played a greater role in characterizing the definitions of more abstract concepts such as ‘risk’ and ‘danger’ than those of ‘prevention’.

In order to check which components better characterized the definitions of each concept, a Correspondence Analysis was performed, the factors of which were the three concepts and the types of the components produced (Figure 5.).

Fig. 5. Correspondence analysis with the 3 S&S domain abstract concepts and their definitional components as factors (Study 2).



On the first dimension, which explained 99% of the total variance, ‘prevention’ characterized by the situational components differed from both ‘risk’ and ‘danger’, which were characterized by introspective, taxonomic, and attributive components. Accordingly, the more concrete components, i.e. the situational ones, characterized the definition of the less abstract concept, i.e. prevention. Instead, the more abstract components, in particular the introspective ones, characterized the definitions of the more abstract concepts, i.e. ‘risk’ and ‘danger’. Thus, even if the definitions produced by non-professionals again rested mainly on

the situational components, the hypothesis that the variety of domains referred to by concepts definitions increases the role played by the more abstract components in definitions was confirmed.

### Discussion

Overall, the results of Study 2 with lay participants replicated those obtained in Study 1, even if there was an interesting difference. As in Study 1, in Study 2 the definitions produced activated mainly situational components. However, in this study the situational components characterized primarily the definitions of the less abstract concept 'prevention', whereas in Study 1 situational components were not differentially activated by the three concepts. As in Study 1, the more abstract introspective components better characterized the more abstract concepts 'risk' and 'danger'. Thus, the asymmetry in the three concepts in eliciting definitions based on different components, already found in Study 1 due to the abstractness degree of the concepts, was replicated in Study 2, but differently.

### Comparison between Study 1 and Study 2

In order to better assess this shift in the components underlying the definitions produced by expert participants referring the three concepts to mainly the S & S at workplace domain, and those produced by lay participants who referred the three concepts to a variety of different domains, a log-linear analysis was performed. The factors of this analysis were the participants (expert participants referring to S & S mainly in one domain vs. lay participants referring to S & S in many different domains), the three concepts ('risk', 'danger' and 'prevention') and the types of components the definitions rested on (situational, introspective, taxonomic and attributive).

On the basis of the test of all marginal and partial associations, the best model that fitted the data was obtained ( $\chi^2$  (d.f. = 12) = 18.133,  $p$  = .112). This model highlighted two significant interactions.

The first interaction was between expert participants referring to S&S in one domain vs. lay participants referring to S&S in many different domains and the types of the components on which the definitions were based (situational, introspective, taxonomic and attributive) ( $\chi^2$  (d.f. =16) = 35.53,  $p$  = .003). This interaction showed the role of situational components in the definitions produced by professionals, who referred the concepts to a single domain, and the role of introspective components in the definitions produced by non-professionals, who referred the concepts to a variety of domains. This confirms that non-professionals refer to more abstract contextual constraints compared to professionals, who can ground abstract concepts in a specific domain, the workplace.

The other interaction was between expert participants referring to S&S in one domain vs. lay participants referring to S&S in many domains and the three concepts ( $\chi^2$  (d.f. =18) = 1292.09,  $p$  = .0001). It showed that the two samples of participants differed in the components used in their definitions of the three concepts, as already highlighted by the Correspondence Analyses.

Professional participants' definitions, besides overall resting on situational components, showed a difference between 'prevention', that was characterized by taxonomic components, and 'risk' and 'danger', that were characterized by introspective and attributive components. Non-professional participants' definitions, instead, presented different components depending on the specific concept to be defined. Definitions of the concept 'prevention' were based on situational components, while those of both 'risk' and 'danger' were based on introspective components. In sum, introspective components characterized

definitions of both experts and students. However, while experts also referred to specific situations pertaining their domain of expertise (i.e. their job) plausibly due to the fact they were interviewed in their workplace, students referred to taxonomic knowledge and drew from a varied pool of experiences (situational components). Introspective components may help in drawing the link between the ‘lived’ definitions of these abstract concepts and more dictionary-like definitions, which are characteristic of managers and students, who, for different reasons, are less bound to refer to one specific situation in their definitions.

### General Discussion

We will outline below the main results concerning the role of situations, the importance of expertise and the role of introspection; then we will discuss the implications of our results for recent embodied theories of abstract concepts.

**Situations.** Our results clearly show that situational information related to particular events and settings plays a prominent role in the definition of the abstract concepts we considered. Situations presumably play a major role in grounding them since abstract concepts do not have single objects as referents. These results confirm and extend those obtained by Barsalou and Wiemer-Hastings (2005) and Wiemer-Hastings and Xu (2005) to a novel domain and with a different task, a definition production one; more generally, they support EG theories of cognition. There is a caveat, however: the definition task we used does not allow us to determine whether the linguistic production is due to the embodied experiences the concepts re-enact or to the different semantic associations evoked by each concept. However, we do not see a real opposition between these two accounts, since situated and embodied experience could be linguistically encoded (Andrews et al., 2014; Barsalou et al., 2008; Louwerse & Connell, 2011).

**Expertise.** Our exploratory study shows for the first time how expertise influences abstract concepts representation. The definitions produced by experts and non-professionals revealed a shift in the abstraction degree of the concepts, due to the activation of different components in the two groups. The more fine-grained analyses we performed with the different components confirm that definitions of workers and security technicians were more influenced than those produced by managers by personal aspects, such as emotions, and by more detailed aspects, as the higher percentage of perception elements and of subordinate elements suggest. It was as if the three concepts were more concrete for the professionals, who grounded them in a single and homogenous domain, than for non-professionals who referred them to a great variety of different domains. Thus, the variety of the domains to which participants referred in defining abstract concepts influenced the conceptual components activated. Focusing on a restricted domain of experience shifted the degree of abstractness of concepts toward concreteness in professional participants. This effect matches the effect of expertise in concrete concepts where the basic level becomes more specific with expertise (Johnson & Mervis, 1998; Tanaka & Taylor, 1991). Overall, this research provides for the first time evidence for the interplay between expertise and the information elicited by concepts at different degrees of abstractness. First, it enhances our understanding of abstract concepts organization providing a detailed analysis on a specific domain. As argued in a number of recent studies (Borghi et al., 2014; Ghio et al., 2013; Setti & Caramelli, 2005), detailed analyses of the differences between different kinds of abstract concepts are much needed. At the same time, our study also shows how expertise modulates this organization. Our study did not simply provide evidence for a generic effect of expertise on definitions of abstract concepts. Also the effect of inter-expert variation, which is well documented in objects’ categories (Diamond & Carey, 1986; Johnson, 2001; Medin et al., 1997; Tanaka & Taylor, 1991), was found to affect the definitions of abstract concepts. Accordingly, the four

groups of professionals in Study 1 produced definitions with different components. Managers, security-technicians, trade union delegates and workers referred to the domain of S&S at the workplaces from different perspectives, like ‘ideals’ (Barsalou, 1985) or ‘theories’ (Murphy & Medin, 1985), as it happens in objects’ concepts. In fact, both managers and security-technicians, who have declarative knowledge implying concrete contextual constraints, as those provided by norms and rules in the S&S domain, produced definitions based on taxonomies. Instead, workers and trade union delegates, likely to have been workers at a previous stage, produced definitions based on introspection implying the more abstract, generic contextual constraints of the risky and dangerous situations they directly experienced.

**Introspection.** Taken together the present results suggest that concepts are rated as more abstract when they are more difficult to ground in a specific context. In line with the Contextual Constraint Theory (Wiemer-Hastings et al., 2001), the more abstract a concept is rated, the more abstract the contextual constraints it activates. Importantly, an increase of abstractness is related to an increase of introspective components, in line with predictions of WAT and partially of AEA.

**Which theory?** Overall, we found that abstract concepts are grounded in situations, activate introspective components, and are modulated by expertise. These findings are difficult to accommodate with traditional views such as the Context Availability Theory, according to which abstract concepts are only loosely related to their context (Schwanenflugel et al., 1988), and the Dual Coding Theory, according to which abstract concepts activate verbal information, while concrete ones activate imagery (Paivio, 1986). Our results can be more easily explained by theories proposing that abstract and concrete concepts differ as to their organizational principles, but are embodied (Dove, 2011; Borghi et al., 2011; Borghi & Binkofski, 2014; Crutch & Warrington, 2005).

Overall, the fact that abstract concepts are grounded in situations and modulated by expertise clearly supports EG theories in general, even if it does not provide direct support neither to the conceptual metaphor theory nor to the action-based view. The role played by introspective properties allows further insight into which theory may best fit the results.

The situation and introspective view can easily account for the results, since the level of abstractness is predicted by the looser contextual constraints and by the higher number of introspective components. AEA could explain the importance of introspective components arguing that abstract concepts activate emotional aspects; consider, however, that this explanation would be only partial since emotional features represent only a subset of the introspective components.

Our results support also WAT, according to which abstract concepts are embodied and activate linguistic information: we namely found that abstract concepts are grounded, because they largely activate situations and are modulated by expertise, and also activate introspective information. In the framework of the WAT proposal, introspective relations can be interpreted as explanations of concepts to oneself, likely mediated by inner talk. Introspective components may highlight the need to relate grounded definitions to a more normative definition (dictionary-like) which can comprise different contexts, more so for workers and delegates whose definitions are more grounded in one specific situation. Since introspective components were found to play a strong role also in property generation tasks (Barsalou & Wiemer-Hastings, 2005; Roversi et al., 2013), we think it can be excluded that the role for introspection is stronger here because of the expectancy of what a definition should be like. Further research is needed in order to understand more deeply the role played by introspective elements in characterizing the most abstract among abstract concepts.

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