



UDC 81'23=111

Original scientific article

Received on 25.3. 2017

Accepted for publication on 12.12. 2017

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Between a prototypical perspective and the conceptual space of LOVE in password creation

Aided by the instruments of prototype theory, the current study sets out to determine whether in password creation there is a common underlying cognitive pattern in the categorization of the elusive natural language concept of LOVE. Our framework combines free listing, a method providing critical information about the words that are more generally associated with a concept, and analysis of prototype rating surveys. The results obtained are compared to a dataset of randomly selected passwords to determine the semantic associations of the concept of LOVE and clarify the semantic processes involved in the structure of passwords. Results suggest that, in categorizing LOVE, password users have compatible representations that afford a meeting of minds. We conclude that LOVE acts as a fixpoint in the mental processing of this CONCEPTUAL SPACE and that it takes, with password users, idealized forms of representations rather than individual experience-based representations, as might be expected. Our investigation method has facilitated the collection of data on how LOVE prototypes specify more exhaustively the mode of synthesis and the cognitive mapping under which these may occur.

Key words: LOVE; prototype; passwords; CONCEPTUAL SPACE; mapping.

1. Introduction*

Prototype theory rests on the assumption that semantic categories have fuzzy boundaries and allow for different degrees of membership. The question is not whether or not a word belongs to a category, but to what extent a word is applicable to a thing (Coleman & Kay 1981). In contrast to the theory of semantic fea-

* Project financed from Lucian Blaga University of Sibiu research grants LBUS-IRG-2016-02.



tures, prototype theory allows such categorizations to be made based on context and personal judgment, and to involve both literal and metaphorical uses of a word.

Holding that various forms of communication determine a system of meanings that becomes shared between interlocutors, Gärdenfors has more recently explained prototype theory in terms of *CONCEPTUAL SPACES*, conceived as multi-dimensional feature spaces (Gärdenfors 2000). Rejecting the idea that the meanings of words are stable and independent of the communicative context, he proposed a new modeling for natural language semantics (Gärdenfors 1996) that could serve as a firm cognitive foundation for *word classes*.

Yet, there is little consensus over the superordinate category of emotion or over the typology of LOVE. The gradedness of membership (or the internal structure) as well as the fuzzy boundaries examined by Rosch (1975; 1977) point to various indices of cognitive processing in the conceptualization of emotion concepts. Such a conceptualization of the emotion category may be substantially informed if/when tested in password creation, an area in which the individual's cognitive structures are characterized by intentionality, cognition, and a meaningful structuring of one's consciousness. Being a world of inner experiences, dreams, and imagery, the world of password creation is structured as a world of finite *provinces of meaning* that define a reality which is "not constituted by the ontological structure of its objects" (Schutz 1945: 551) but is rather shaped by individuals' experience of that reality and by the meanings they attach to objects. Aiming to obtain maximal information with minimal processing effort, the human mind is likely to operate on relevance-based principles and to structure information that comes with a certain guarantee of relevance. It has been found that two thirds of one's passwords are designed around one's personal characteristics and another third is related to family, lovers, and friends (Brown et al. 2004). This makes password creation a most fruitful research area. Namely, by examining relevance-based structuring of information, we may gain fresh insight into the natural category of LOVE and its prototype structure. Starting from the prototypical perspective embraced by Fehr and Russell (1991) and drawing on Gärdenfors' *CONCEPTUAL SPACES* prototype theory (1996; 2000; 2004) as well as on Manoharan & de Munck's recent study on the conceptual relationship between LOVE, ROMANTIC LOVE, and SEX (2015), the overarching goal of this study is to examine the semantic associations of the concept of LOVE and to determine whether, in the categorization of LOVE, there is an underlying cognitive mapping between individual meaning spaces, which would lead towards a "meeting of minds". We hold that conceptualized LOVE knowledge does not emerge on the basis of concept allocation to embodied individual experiences, but rather as a mapping between individual LOVE meaning spaces, a mapping of a MEETING OF



MINDS (Warglien & Gärdenfors 2013). The analytical framework of the study combines free listing and the analysis of prototype rating surveys, and tests the obtained results across a dataset of 65,536 randomly selected passwords from UNIQPASS, a password dictionary wordlist used for password recovery tools (<http://thetechofcomputer.blogspot.ro/2014/12/large-password-list-free-download.html>). The approach that we propose helps to explain the semantic processes underlying the composition of passwords.

The study is divided into the following sections. Section 1 provides an introduction to the purpose of the study. Section 2 presents the background and related work in the form of an overview of recent research on prototype theory (Section 2.1.), CONCEPTUAL SPACES (Section 2.2.), and password creation (Section 2.3.). The methodology section (Section 3) outlines the steps of our research. The results are discussed in Section 4. The conclusions of the study are given in Section 5.

2. Background

2.1. *Prototype theory and the categorization of emotion and LOVE*

Prototype theory entered into the categorization literature through the seminal work of Rosch (1973) and her colleagues (Rosch et al. 1976; Mervis & Rosch 1981), who examined how people categorize things and how, in the categorization process, some members of a category are found to be more central/peripheral than others. In more contemporary theories, construction grammar and cognitive linguistics, categories are formed by categorization processes such as distributional analysis and analogy (Langacker 1987; Goldberg 2006). While Langacker maintains that semantic characterizations must rely on centrality and network organization, Lakoff's research (1982; 1987) centers on boundary phenomena and cases of unpredictable category membership, triggered by context-specific communicative-based variations. In particular, Lakoff's notions of *idealized cognitive models* (ICMs) and *interpretive frames* represent new paradigms of mental concept formation and knowledge constructs emerging from the new role attributed in prototypicality to "exposure, conspicuity and salience" (Florea 2014: 946) and to the flexibility of the centre-periphery relationship in semasiological structure description.

Besides lexical and cognitive semantics (Lakoff 1987), tenets of the prototype theory have been also found instrumental in language acquisition (Ibbotson & Tomasello 2009) and other non-linguistic, psychology-grounded fields such as categorization behaviour (Boswell & Green 1982; Buss & Craik 1983; Ford 2003), trait



categories and stereotypes (Cantor & Mischel 1979; Steele et al. 2002), and/or social intelligence (Cantor et al. 1982).

In categorizing emotions, concepts may cluster as prototypes (Russell 1991) or knowledge categories whose members share certain similarity features (Zinck & Newen 2007). The prototypicality of emotion words has provided an important vantage point in the cross-cultural architecture of emotion. Such perspectives have emerged in critical studies focusing not only on the English language (Russell & Bullock 1986; Fehr & Russell 1984; Russell & Fehr 1989; Conway & Bekerian 1987; Iaccino 1989; Lakoff 1987; Fehr 1982; 1988) but on other languages as well (Bormann-Kischkel et al. 1990; Lutz 2011; Russell et al. 2013).

At the core of the prototypical perspective on the category of emotions (Fehr 1984; 1991; 2006) rests the idea that category membership is decidedly resemblance-based. Members belong to a category if they exhibit a sufficient resemblance to prototypical exemplars. Since resemblance is largely a matter of degree, membership in the category varies with *internal structure* and *hierarchy* (Rosch 1977) with no sharp boundary separating members from nonmembers. Furthermore, at the middle taxonomic level, which may include an indeterminate number of categories and subcategories, the emotion domain is characteristically an inclusive one. It consists of central, prototypical emotions that shade off into peripheral emotions that shade off into fuzzy non-emotions. This means that the semantic category of emotion has blurry edges and allows degrees of membership. The applicability of a word to a thing is *not* a matter of ‘yes or no’, but rather of ‘more or less’. According to research results obtained by Fehr (1982; 1988; Fehr & Russell 1984; 1991; 2006) confirmed Rosch’s (1977), the superordinate concept of emotion possesses an internal structure, reflected by its prototypicality score and indexes of cognitive processing of emotional concepts. Conceptually, and somewhat against the idea of a prototypical categorization of emotion, several studies maintain that the category of emotion should be inclusive of “semantic primitives” such as anger, happiness, fear, sadness, and disgust, acting as a “place-holder” for a set of mental states (Johnson-Laird & Oatley 1986). Other approaches consider that emotion terms are nothing but mental states or “affects” that contrast with a physical state or other sorts of cognitions (Ortony et al. 1987).

Little consensus has so far been reached by researchers on how the structure of emotion should be assessed, whether in categorical, hierarchical, or dimensional terms. It is also unclear whether emotion or *affect* is clusterable in unipolar or bipolar concepts, or better still, in simple or circumplex structures (Russell & Barrett 1999). In summarizing research on the category of emotion, Russell and Barrett



found that, over the span of only six years (1991–1997), the Journal of Personality and Social Psychology published 359 articles exploring either categorization issues of emotion or some other structural dimension of emotion. The large body of research on emotion represents one third of all research topics listed in the journal and reflects the wealth and heterogeneous nature of the concept. In an attempt to explore how distinguishable sorts of events fall into the category of *emotion*, Russell and Barrett distinguish CORE AFFECT from the PROTOTYPICAL EMOTIONAL EPISODE. The former has a bipolar nature, being a consciously accessible process of pleasure and activation; the latter represents a more elaborate process that subsumes both categories (such as anger, fear, shame, etc.) and causally connected sub-events. In general, PROTOTYPICAL EMOTIONAL EPISODES engender evaluations of behaviour, experience, cognition, and CORE AFFECT. Therefore, to capture as many PROTOTYPICAL EMOTIONAL EPISODES of LOVE as possible, all components and all forms of cognitions and behaviours involved must be included. Similarly, other *cognitive theories* foreground the significance of the cognitive construct for emotions, holding that the propositional attitudes give individual content to an emotion (Gordon 1987; Lyons 1980). In contrast, the so-called *feeling theories* are generally unable to account for unintentional and unconscious emotions, exploring for example the intentional structure of meta-emotions (Jäger & Bartsch 2002).

The fuzzy, yet unsettled, conceptual relationship between LOVE, ROMANTIC LOVE, and SEX, including other categorizing issues arising from the semantic associations and polysemous nature of LOVE, have been recently explored by Manoharan & de Munck (2015) on the basis of free listing and prototype analysis. By combining the obtained comparative prototypicality ratings and free list frequencies of the terms, they found that ROMANTIC LOVE, a subcategory of LOVE, is typically inclusive of SEX by association rather than taxonomically or categorically via what they term an “associational bridge”. The existence of such an “associational bridge” that cognitively associates the concept of ROMANTIC LOVE with SEX ultimately indicates that ROMANTIC LOVE emerges as a unifying construct of two separate prototypes and their associated semantic categories.

Other research on LOVE indicates that ROMANTIC LOVE is peripheral to other types of LOVE (Berscheid & Meyers 1996; Fehr & Sprecher 2009), and that the most prototypical variety of LOVE is MATERNAL LOVE (Fehr 1988; Fehr & Russell 1991). Fehr (1988) lists the five most prototypical traits of LOVE: HONESTY, TRUST, FRIENDSHIP, CARING, and RESPECT. These are deep-seated in family values and are conceptualized in terms of prototypes.

If much of previous research was dominated by contrastive approaches to the



category of emotions, spanning the classical and the prototype views (Fehr 1988; Russell 1991; Russell & Bullock 1986; Mascolo & Mancuso 1990), more recently, emotion has been viewed as a simultaneously socially constructed and biologically evident repository of *instances* (Barrett 2012). Instances of emotion result from personal instrumental learning acquired through embodied semantic knowledge, social reality, and personal experience (Vigliocco et al. 2009). With growing evidence and promising results from the field of neuroscience on the role of language in the acquisition of emotion concepts, other recent studies have looked into how language is critically involved in both emotional experience and emotion perceptions. Of particular interest has become the way in which conceptualized emotion knowledge emerges from concept allocation to embodied experiences during ongoing processing of sensory information. In addition, researchers have examined emotion words and their conceptualization for their significant implications in both psycholinguistics (Kousta et al. 2011; Barrett 2012; Borghi & Binkofski 2014) and second/first language acquisition (Opitz & Degner 2012).

2.2. Theories of “CONCEPTUAL SPACES”

Addressing *representation* with the tools of cognitive science – psychology, philosophy, logic, computer science, and linguistics – and resting on the conceptualist approach (defended by Langacker, Talmy, Lakoff) that viewed cognitive semantics as a cognitive mapping between language and world representations, Peter Gärdenfors (1996; 2000) has shown that CONCEPTUAL SPACES can be more promising and better instruments for the modeling of natural language semantics. As early as the 1980s, Stevan Harnad (1987) attempted to explain how categories are learned and represented, claiming, in his theory of three-level-representations, that the process of iconic representation is determined by changes that exaggerate some differences while discarding others. In his view, it is such an omission of detail that may lead to more generic results, making it possible for the symbolic representation to stand for a whole class of items. Regarding categorization as a basic cognitive activity that is both instrumental and indispensable in any differential responding task, Harnad was concerned, particularly in what regards the power of symbolic representation to approximate any other kind of representation, with how much categorical representation is needed in order to ground the symbolic system. From a related perspective, Gärdenfors’ key idea of CONCEPTUAL SPACES rests on a similar framework for representing knowledge at concept level. He proposes a semantic theory that helps clarify the field of semantics, the relation between CONCEPTUAL SPACES and semantic domains, the cognitive grounding of word classes (nouns, adjectives,



verbs, and prepositions) as well as the cognitive theory of actions/events and the compositionality of meanings.

According to Gärdenfors (1996; 2000; 2004), a CONCEPTUAL SPACE is a mathematical structure that has a number of metric-based qualitative dimensions. Quality dimensions constitute the building blocks of representations within a CONCEPTUAL SPACE and they are inclusive of such dimensions as temperature, weight, size, and volume, combined with the height, width, and depth dimensions. The intersected features of a point across a CONCEPTUAL SPACE mark specific illustrations of each dimension, e.g. a specific weight or a distinct size. The dimensions correspond to different ways of perceived similarity or difference and indicate that the farther apart two points are within a space, the more dissimilar they tend to be. On such a basis, assessments of similarity and difference will determine a certain *ordering relation* of perceptions within a framework that is designed to attribute *properties* to objects and to indicate *relations* among them. In other words, a concept comprises not only a bunch of properties but also information about how those properties are correlated, e.g. the concept of an apple has properties corresponding to regions of size space, taste space, nutrition space, shape space, and so on (Gärdenfors 2000; 2014). Such distinctness between properties and concepts allows for an analysis of the cognitive roles of word classes. Gärdenfors (2000) regarded properties as being typically expressed by adjectives and concepts (representing properties from a number of domains) as being typically expressed by nouns. He later extended this analysis to the cognitive mechanisms of verbal communication and verbs (Warglien & Gärdenfors 2012; Warglien et al. 2012)

QUALITY DIMENSIONS form clusters called DOMAINS. In trying to explain how sharing of semantic domains occurs in language acquisition, Gärdenfors (2000; 2014) takes the example of a 4-year-old child for whom the colour meanings of *chartreuse* and *mauve* are easier to grasp than those of the monetary terms *inflation* and *mortgage*. According to him, such difficulty arises from the fact that the child has an already available internalized domain of colours. In other words, domains are not inherently in-born, but rather humans learn them so that language understanding depends on sharing semantic domains. A CONCEPTUAL SPACE consists of one or more domains together with a notion of distance (a metric). It is the geometric structure of CONCEPTUAL SPACES that makes it possible to determine distances and the distance in the CONCEPTUAL SPACE represents an indicator of semantic similarity. Not all domains are generally metric-based – a domain may be non-defined distancewise – and within domains correlations may be established, e.g., the domains of shape and ripeness may co-vary in the CONCEPTUAL SPACE of fruits.



Concepts are established CONVEX regions of CONCEPTUAL SPACES (Gärdenfors 1996; 2000) and a concept maps a CONVEX region in one or more domains. Concepts encapsulate not only domain prominence values but also significant information on how regions are associated in various domains. The argument of CONVEXITY helps explain why metaphorical terms are used for more abstract ideas, and why ideas can be further taken into non-perceptual areas. In addition, convexity makes learning efficient, speeding up the process of learning (Gärdenfors 2000) being equally critical in ensuring the *effectiveness of communication* (Gärdenfors & Warglien 2012). For the purpose of our study, CONVEXITY of CONCEPTUAL SPACES is treated in connection with prototype theory (Rosch 1973; 1977; Mervis & Rosch 1981) as it allows a region to be inclusive of positions that can be described as being more or less central. If colour concepts similar to the convex subsets of the conceptual colour space (focal/primary colours) are considered, then the central points of these regions constitute the most prototypical illustrations of the colour. Consequently, the metric that determines the space can be used to allocate to each prototype all the points in the space that lie closer to it than to any other prototype. This rule breaks up the space into a collection of convex regions, through the so-called VORONOI TESSELLATION, a mechanism that provides “a constructive geometric answer to how a similarity measure together with a set of prototypes determine a set of categories” (Warglien & Gärdenfors 2013: 11). The boundaries produced by Voronoi tessellations provide the threshold of similarity and support a mechanism that explains categorical perception. Prototypes are also apt to generate cognitive economy. Unlike in case-based reasoning, the prototype is sufficient in the economy of the space because, having a single average, all borders can be determined (with reference to the prototype).

From a social perspective, the relation between individual speakers and their communal language remains an important perspective of cognitive semantics. Putnam’s theory (1975), a protest in fact against the conceptual analysis of meaning, advanced the famous tenet “meanings ain’t in the head” that substantiates the assumptions that the meaning of a term (1) determines its extension, and (2) is determined by a certain psychological state. Gärdenfors argues that sharing mental representations results in emergent semantics. If individuals have their own mental space, then how can a representation be the meaning of a particular expression? He holds that semantics is communication-based, as meanings are constructed during communicative interactions. His socio-cognitive approach proposes semantics as the “meeting of minds” (Warglien & Gärdenfors 2013), a meeting of all mental structures that are different for different individuals, semantics being thus a mapping between individual meaning spaces. On such a basis, the meanings of expres-



sions are not contained in the individuals' mental representations; rather they *emerge* in a meeting of minds prompted by active interactions between language users. Our acceptance of the notion in the current study represents a slight departure from Gärdenfors who maintains that meanings result from speakers' communicative interactions. In password creation there is no dynamic *communicative* process involved, hence it is only *the static* cognitive MEETING OF THE MINDS perspective that is under consideration. We only take the MEETING OF THE MINDS view to mean that the representations that emerge in the language users' minds are sufficiently compatible when minds cognitively meet on the common referent of LOVE.

2.3. Password creation and the search for grammatical structures

The Internet has progressed to become the most complicated human-made system in history. However, with so much password use in computing science and computer security, there is still hardly any thorough understanding of how people create their passwords.

The structure of passwords has been so far examined from several perspectives. From a psychological and mental perspective, based on the results from a NIST-funded national survey, Chisnell & Newby (2015) explored the cognitive context of password use and the main strategies for password creation. Premising their research on the idea that password security practices generally interfere with general usability principles, Rinn et al. (2015) extended the survey and profiled it on low-literacy users to gain important insights into the patterns of use, cognitive demands, mental models and challenges faced by such an at-risk category of users. From a semantic point of view and largely drawing on psychological instruments, Brown et al. (2004) found that two thirds of one's passwords are designed around one's personal characteristics and another third is related to family, lovers, and friends. In addition, their study reveals that, in fact, a good half of all password creation rests on the primary information provided by birthdays and proper names. Along the same lines, Riddle et al. (1989) and Klein (1990) found that self-generated passwords are very often common words related to users' biographical data, or their immediate environment (nicknames, personal, and celebrity names). Other attempts investigated grammar and grammatical rules to crack passphrases (Rao et al. 2013), exploited context-free grammars (Weir et al. 2009), or explored general linguistic patterns in multi-word passphrase selection (Bonneau & Shutova 2012).

Rao et al. (2013) studied the role of grammatical structures in password creation and cracking and found that password strength is neither length-based nor length-



determined. Using a POS-based analytical model, they showed that grammatical structures in long passwords may in fact determine a decrease in the search space by more than 50%. The study shows that long passwords represent a most promising user authentication mechanism with significant implications for passphrases policies. Weir et al. (2009) designed a method used for generating password structures in the highest probability order. The probabilistic context-free grammar (PCFG) that they proposed allowed them to create a word-mangling algorithm that helps increase the number of password guesses.

Bonneau & Shutova (2012) examined patterns of human choice in multi-word passphrases and found that users choose passphrases that display natural language properties, manifesting a strong preference for simple noun bigrams that are common in natural language. For all the apparent limitations of their dataset (over 100,000 possible phrases extracted from the Amazon authentication system), their findings suggest that users do not choose phrases that consist of completely random words, but rather they are highly influenced by the probabilities of phrase occurrences in natural language.

More recently, Veras et al. (2014) have explored the semantic patterns of passwords and their implications for online security. For the first time, they designed a framework for segmentation, semantic classification, and generalization of passwords based on Natural Language Processing (NLP) algorithms. Such a computational linguistic model, (emerging from the RockYou data set of leaked passwords and then extended to the LinkedIn and My Space datasets), can be used to generalize semantic categories based on the semantic profile of passwords. Their functional model, retaining the semantic essence of password samples, is clearly more advanced than Weir's (2009) method whose main limitation is that of not being "able to assign realistic probabilities to alphabetic words, nor capturing their relationships" (Veras et al. 2014: 2). Other limitations include ignoring semantic rules (fewer overall terminals), and treating grammar and dictionary input separately.

Ur et al. (2013) explored password strength from the novel perspective of the relationships established between the component pieces of passwords. In particular, their study considered the extent to which knowing one chunk of a password provides an advantage for guessing the subsequent part. While some previous research had already established that passwords contain words (Campbell & Bryant 2004), Ur et al. examined the POS-tag distribution between the password and natural language and found that passwords are more likely (than English) to contain nouns and adjectives, but less likely to contain adverbs and verbs.



In the recently emerging literature on passwords, other researchers, with a more vested interest in mechanisms of password cracking, have resorted to linguistics to seek more aids in finding structural patterns for better grounded strength metrics. Jakobsson & Dhiman (2013) propose a parser of passwords that learns the component frequencies (including alphabetic strings) and proves instrumental in scoring password strength and blocking weak passwords. Komanduri et al. (2014) devised a Telepathwords technology that defies traditional composition rules and makes real-time predictions for the next character that password users will type. Sparell & Simovits (2016) explored password cracking by modelling the language of passphrases on a Markov process. Their findings show the practicality of creating models of language, by means of which linguistically correct passphrases of up to 20 characters can be broken faster by comparison to an exhaustive brute-force search. Wang et al. (2016) picked up the challenge and demonstrated that the current leading password strength meters (PSMs), including probabilistic context-free grammar and Markov-based ones, are still inaccurate and weak at gauging weak passwords. For practical purposes, they devised a fuzzy PCFG-based meter that is grounded on real use behaviour and operates dynamically on how users choose passwords. A list of well over 500 contributions, compiled on the password research site: <http://passwordresearch.com/papers/pubindex.html>, reflects not only the magnitude of the research done to date but also the huge interest in the field. All these studies set out to examine an ever-increasing diversity of methods that are capable of better exposing the vulnerability of current password creation practices. So far, such vulnerability has been identified as emerging from lexical patterns (e.g. word choices from preferred or own environment), structural preferences (in composition rules) and, only to a small extent, syntactic and semantic patterns (e.g., preference for semantic categories and their sequences). Most of such research examines password creation in controlled experiments exploring various password strength meters and creation policies. However, very few have indicated the relationship between semantic choice and relevance of passwords as well as the extent to which such a relationship can further diminish the search space of passwords. No research has so far been conducted on either the prototypicality of emotion words in password creation or on the mental representations clarifying the semantic processes involved in the structure of passwords.

3. Methodology

The current research was conducted on a list of 65,536 leaked passwords from UNIQPASS. The list of passwords (hereinafter referred to as password list) has



provided a rich, complex, and most challenging area of investigation, as little is currently known about how individuals make use of personal and restricted information in password creation. Much less is still known about what really happens in the space created between the layers of the human brain's complexity and the final keyboard strokes on the computers' starred-out password field. Our examination is both corpus-driven and corpus-assisted. Moreover, it was conducted on a password corpus that provides no information whatsoever on the age of our demographic sample, on nationality of password users, time limit for password creation or on any other contextual factors that may determine conceptualizing processes or password usage. This makes our research extremely important for password creation all the more so as our findings will have very strong implications not only for all password users' cognitive processes but also for their most (proto)typical mental representations of the abstract emotion concept of LOVE

The methods for data collection are free lists and surveys, resting on previous research conducted by Fehr (1988), Fehr & Russell (1991) and Monaharan & de Munck (2015). The novelty of our approach lies in the selection of our corpus, which is a password dictionary wordlist that is used for password recovery tools (available online at: <http://thetechofcomputer.blogspot.ro/2014/12/large-password-list-free-download.html>). Our method applies free listing (a method that gives us critical information about the words that are more generally associated with a concept) and analysis of prototype rating surveys, and tests the obtained results across the 65,536 randomly selected passwords from UNIQPASS so as to determine whether there is an underlying common cognitive pattern in the categorization of LOVE that is shared by both our sampled category of respondents and anonymous password users.

For this purpose, firstly we address the issue of semantic associations of the elusive concept of LOVE by using free listing with a sampled category of respondents. This method helped us to elicit the key terms with which the category of LOVE is usually associated. Subjects in the first study (Study 1) were students of different nationalities, with a mean age estimated at 21.6 years (roughly half were male, half female), who volunteered to participate in the study. The free lists were collected over one month and frequencies and percentages were calculated. The second study (Study 2) provided the data set that was obtained by collecting surveys from the same demographic group as the free lists but not from the same individuals. The mean age of survey respondents was 23.2 years (roughly half were male, half female). A different group of respondents was chosen so as to enlarge the investigation area and diversify the sample of respondents. The analysis of prototype rating surveys allowed us to assess the placement, and the goodness-of-example ratings



for each LOVE subtype association obtained in Study 1. A 3-point scale of prototypicality was used, listing 1 as *not important*, 2 *somewhat important*, and 3 as *most important*.

The third study (Study 3) was carried out on the password list and aimed to establish the occurrence of the word LOVE in the password list. For that purpose, the search used the tag LOVE across the whole list of passwords and the frequency and percentage of occurrences were determined. Data cleansing and data validation required that /LOVE/, or its variant /luv/, be either a noun or a verb identifiable in the emerging structures. Next, the top-10 terms for LOVE from the free lists (obtained in Study 1), were tagged and their occurrence frequencies were calculated, listing from highest to lowest. A (mis)match between the free listing results of Study 1 on the one hand, and the top-10 subtypes for LOVE across the password list on the other, was sought so as to confirm the existence/absence of an underlying common cognitive pattern in the categorization of LOVE, mapping individual meaning spaces via a “meeting of minds”.

4. Results and discussion

The free lists generated by the subjects in the first study (1) included 296 key terms in which the respondents placed their concept of LOVE. In their responses to the question: “What terms do YOU associate LOVE with?”, the subjects provided several semantic associations of LOVE, reflective of their mental representations of LOVE. Words were then further grouped according to similar meaning (e.g. husband/wife = spouse; passionate LOVE = passion; LOVE of country = patriotism, etc.) or falling into the same group (e.g. crude, biological sex terms = sex). Resulting from such grouping, a final list of 19 terms emerged and, for each item, the percentage and frequency were calculated (Table 1). Of these, the top-10 groups were further targeted for examination in Study 3.

Somewhat predictably, the results obtained indicate that the 10 most frequently listed terms were SEX, FRIENDSHIP, FAMILY, PASSION, MARRIAGE, COMPASSION, TRUST, DATING, COMMITMENT, and HAPPINESS. SEX and PASSION have been already found in Manoharan and de Munck’s study (2015) to be most commonly associated with LOVE whereas Fehr’s study (1991) indicates FRIENDSHIP and SEXUAL LOVE as the most prototypical members of the concept of LOVE.



Table 1. Top 19 terms emerging from the free lists (ordered from highest to lowest)

	LOVE	Frequency	Percentage
1	Sex	24	2.75
2	Friendship	22	2.52
3	Family	20	2.29
4	Passion	19	2.18
5	Marriage	18	2.06
6	Compassion	17	1.95
7	Trust	16	1.83
8	Dating	16	1.83
9	Commitment	16	1.83
10	Happiness	15	1.72
11	Desire	13	1.49
12	Togetherness	13	1.49
13	Understanding	10	1.14
14	Nature	9	1.03
15	Brotherhood	8	0.91
16	Selfish	8	0.91
17	Sharing	8	0.91
18	Music	3	0.34
19	Patriotism	1	0.11

The terms obtained showed a significant presence on the free lists, hence they were expected to point to a significant degree of prototypicality to their respective category. This analysis formed part of the second Study (2), in which each of the 10 LOVE subtypes (mental representations of LOVE) from Study 1 was rated for their prototypicality on a 3-point scale that listed 1 as *not important*, 2 *somewhat important*, and 3 as *most important*. Table 2 shows these prototypicality ratings.

With reference to centrality vs. periphery distinctions, a decision was made regarding the median divide of the listed prototypicality ratings. COMPASSION, HAPPINESS, TRUST, FRIENDSHIP, MARRIAGE, and PASSION were taken to be central, with ratings above 2.08 on the 3-point scale, whereas FAMILY, SEX, COMMITMENT, and DATING, having ratings lower than 2.08, were taken to be peripheral.



Table 2. Prototypicality ratings from 1 to 3 for LOVE

	LOVE	Rating
1	Compassion (6)	2.42
2	Happiness (10)	2.32
3	Trust (7)	2.16
4	Friendship (2)	2.13
5	Marriage (5)	2.11
6	Passion (4)	2.08
7	Family (3)	1.78
8	Sex (1)	1.72
9	Commitment (9)	1.70
10	Dating (8)	1.67

Note: Numbers in brackets represent the freelist ranking of LOVE-subtypes.

Unlike previous research (Fehr & Russell 1991; Monaharan & de Munck 2015), the current study did not set out to verify the mean reaction times, viz. specifically how long our subjects took to rate central members by comparison to peripheral ones. Also outside the scope of our study was whether the subcategories of LOVE were rated differently by female and male respondents. Although several findings suggest a distinction between women's more *companionate* kind of LOVE and men's more *passionate* LOVE (Traupmann & Hatfield 1981), or women's more down-to-earth views about LOVE as opposed to men's more romantic ones (Peplau 1983), our research was premised on the correlation already established between women's and men's ratings of prototypicality of various *characteristics* of LOVE (Fehr 1988). Our obtained prototypicality ratings (Table 2) conform to previous research (Fehr & Russell 1991; Monaharan & de Munck 2015) in that companionate attributes of LOVE are rated as the most prototypical whereas the more passionate, sexual-driven attributes (sex, dating) are least prototypical. Moreover, all ten attributes show a progressive shading into less, somewhat overlapping, prototypical attributes. Additionally, results point to a noticeable reversion of subtypes, with free-listed terms ranking higher as prototypically most important subtypes of LOVE (e.g. COMPASSION (6), HAPPINESS (10), and TRUST (7)).

Study 3 was based on the password list with a threefold purpose: (1) to establish the occurrence and frequency of the word *love* in the password list; (2) to establish the frequency of the top-10 free-listed terms for LOVE in the password list so as to determine whether free-list choices match password list choices; (3) to establish the frequency of the most prototypical terms for LOVE (Study 2) in our password list so as to generate a contrasting dataset for both top-10 free list and prototypical terms.



Table 3. Grouping of transitive associations and their occurrences

Transitive LOVE associations	Occurrences of transitive LOVE associations
Science	8
Music	22
Family	40
Person (male, female)	53
Geography (City, Country)	18
Animal	27
Sport	10
Nature	6
Plant	5
Food	15
Humanity	4
Self	6
Crude terms (sexual organ)	85

The results obtained indicate that out of 65,536 passwords, 351 password structures contain the word *love* in the initial, mid- or final position, preceded or followed by numbers. *Love*-containing passwords account for 0.53% of all passwords. Out of the 351 password structures that contain the word *love*, 298 are of the S-P-Od type. These groupings of transitive associations and their respective occurrences are listed in Table 3.

The search results of the 10 free-list terms across the password list and their frequencies, together with the 10 most prototypical terms for LOVE rated in Study 2 were further contrasted to the password list frequencies in Table 4. The bolded list of terms represents the emerging ranking of LOVE subtypes from our password examination.

The results indicate a surprisingly close resemblance between free list terms and password list frequencies, with only TRUST, DATING, and HAPPINESS ranking two levels higher and MARRIAGE four levels lower in our password analysis corpus.



Table 4. Comparison of free-listed and prototypically-rated terms and their password list frequencies in Study 2 and 3

Top-10 free list terms	Free list frequency	Password list frequency	Prototypically rated subtypes of LOVE	Password list frequency of prototypical words	Emergent ranking of subtypes of LOVE
1. Sex	24	55	Compassion	2	1. Sex
2. Friendship	22	13	Happiness	13	2. Family
3. Family	20	11	Trust	5	3. Happiness
4. Passion	19	10	Friendship	13	4. Friendship
5. <i>Marriage</i>	18	2	Marriage	2	5. Passion
6. Compassion	17	2	Passion	10	6. Trust
7. <i>Trust</i>	16	5	Family	23	7. Dating
8. <i>Dating</i>	16	3	Sex	104	8. Compassion
9. Commitment	16	0	Commitment	0	9. Marriage
10. <i>Happiness</i>	15	2	Dating	3	10. Commitment

An ascending trend is reflected cross-sectionally in the emerging bolded top-down ranking of LOVE subtypes that lists TRUST as number 6, DATING as 7 and HAPPINESS as the 3rd password-embedded LOVE subtype. Moreover, a comparison between the frequencies (calculated as the number of times an item appeared) of free list and prototypical terms on the one hand, and the password ranking of LOVE subtypes on the other, shows that the latter is more similar *in ranking order* to the free list terms (Study 1) than to the prototypically-rated terms (Study 2). This similarity is a very interesting finding of our research that entitles us to believe that there is an underlying pattern in the categorization of LOVE that has to do more with a common semantic cognitive processing involved in password creation than with an arbitrary structuring of information by passwords users.

Part of the explanation resides in the human tendency to maximize relevance as a result of cognitive systems development. This is a property attributable to utterances, thoughts, and memories and has maximal implications for both semantic categorization and pragmatic interaction. Research has already shown that human categorization rests on the function-based principles of *cognitive economy* (Rosch & Lloyd 1978) and structure of the perceived world. Both principles determine not only the conceptualizing level of abstraction of categories but also the internal structure of those categories. By observing length restrictions and compositional



rules, password users are forced to comprise maximal information for a minimal password processing effort, information that is retained with a certain guarantee of relevance. Little is known, however, whether the degree of abstraction determines conceptual relevance in cognitive processes. Ideally, if categories map the perceived world structure as closely as possible, then maximum information is achieved with the least cognitive effort. As the degree of relevance grows with the number of effects derived but diminishes with the load of processing effort necessary for their production, password creation admittedly retains an identifying mechanism of expected contextual effects that would be consistent with the password user's aim of attaining relevance for a minimum information processing cost. Relevance thus remains a question of maximizing circumstantial effects and minimizing processing effort. In this respect, mnemonics becomes important in its provision of encoding and retrieval cues that allow for efficient storage and subsequent retrieval.

We hold that that the conceptualizing mechanisms in password usage are under the constraints of memory retrieval mechanisms. Such mechanisms are apt to activate potentially relevant representations (subtypes of LOVE) and maximize categorization in becoming associated with something more meaningful but long-lasting on an individual basis. In more specific terms, LOVE conceptualizing by password users requires that the category of LOVE be not only relevant enough but also that such a degree of relevance be the highest level possible, given their interests, attributes of LOVE, and preferences. This degree of relevance explains why free-list terms for LOVE are more similar *in ranking order* (hence frequency of occurrence) to LOVE-embedded passwords but differ from the prototypically-rated terms in individual respondents. Both free list terms and LOVE-embedded passwords are created by mechanisms that allow for the cognitive processing of CORE AFFECT and not of PROTOTYPICAL EMOTIONAL ATTITUDES (Russell & Barrett 1999).

Since CORE AFFECT and PROTOTYPICAL EMOTIONAL EPISODES of LOVE refer to different representations and are conceptionally separable, the mechanisms of categorizing CORE AFFECT (as most basic, consciously accessible feeling, such as: a sense of pleasure, happiness, or elation, etc.) and PROTOTYPICAL EMOTIONAL EPISODES, (as interrelated sub-events concerned with a particular object, person, or event, that can be real or imagined) must be different as well. The conceptualizing processes of the free lists and the password list are much alike and are both more likely to facilitate reference to what might be generally termed as LOVE of (therefore a CORE AFFECT representation) and not a PROTOTYPICAL EMOTIONAL EPISODE of LOVE, represented in the form of the *in LOVE with* type. The results obtained point to such a different cognitive representation. The prototypically-rating exercise



of Study 2 yields a much different ranking of subtypes of LOVE than the ranking resulting from the password list. This is because respondents in the former rate in fact the PROTOTYPICAL EMOTIONAL EPISODES of LOVE (which are taken to represent for instance an abrupt change in CORE AFFECT in response to some personal experience or event) whereas the password users in the latter refer to the *more general* CORE AFFECT of LOVE. The parallel examinations conducted on the free lists and emerging from the survey respondents on the one hand, and on LOVE categorizing by password users on the other, have led us to results that underscore not only the importance of LOVE in categorization processes of emotion but also the fact that qualitatively different kinds of LOVE may fall under the term.

In password creation, categorization of LOVE has more to do with a common semantic cognitive processing involved in password creation than with an arbitrary structuring of information by passwords users. More contribution towards the understanding of this underlying pattern comes from Gärdenfors (2000; 2004) and his geometry of meaning theory that establishes concepts as *convex* regions of CONCEPTUAL SPACES. We hold that password LOVE conceptualization is a symbolic representation made on judgments of similarity that are central for a generally large number of cognitive processes. In Gärdenfors' view, a CONCEPTUAL SPACE (a group of one or more domains) is a domain-based cognitive structure and an object may be described by certain properties irrespective of other properties. Thus he holds that the emotion domain, much like in Russell's view (1980), is defined by two basic dimensions: on the one hand, a scale value dimension reflective of positive to negative forms of emotions, on the other, a scale arousal dimension indicative of a range of calm to excited emotional states. Distances in the emotive space indicate degrees of similarity between emotions. The results of our study, in particular the findings of similarity in the ranking order between the password list and the free list terms, show that in the case of passwords, conceptualized LOVE knowledge emerges not on the basis of concept allocation to embodied individual experiences but rather on the basis of a mapping between individual LOVE meaning spaces, a mapping of a MEETING OF MINDS (Warglien & Gärdenfors 2013). As already stated, our acceptance of the notion represents a slight departure from Gärdenfors, who maintains that meanings result from the speakers' communicative interactions. In password creation there is no dynamic *communicative* process involved, hence it is only *the static* cognitive MEETING OF THE MINDS perspective that has been under consideration. We have taken the MEETING OF THE MINDS view to mean that the representations that emerge in the language users' minds are sufficiently compatible when minds cognitively meet on the common referent of LOVE. Emerging from our results, an idealized, static, categorization of LOVE allows password users to main-



tain a concept of LOVE that renders them as being in unifying compatible states of mind. Their mental LOVE representations afford meetings of minds, in which LOVE acts as a fixpoint in the mental processing of this CONCEPTUAL SPACE.

5. Conclusion

A mixed approach combining free lists and analysis of prototype survey on the one hand with password list examination on the other has helped us to inquire into the mechanisms of the categorization of LOVE in password creation and to determine whether such categorizing is made on the basis of a common underlying cognitive pattern by password users. The present study extends previous research conducted by Fehr (1988), Fehr & Russell (1991), and Manoharan & de Munck (2015) on the prototypical analysis of LOVE. In addressing (a) the polysemous nature of LOVE, (b) the semantic associations of this concept, and (c) whether the cognitive categorization pattern of LOVE represents a mapping of individual meaning spaces via a MEETING OF MINDS, we have resorted to prototype theory in cognitive linguistics and Gärdenfors' theory of CONCEPTUAL SPACES, both of which have proved helpful in understanding the cognitive foundation for the emotion category of LOVE. Results suggest that in categorizing LOVE, password users have compatible representations that afford a meetings of minds. We hold that LOVE acts as a fixpoint in the mental processing of this CONCEPTUAL SPACE and that it takes, with password users, idealized forms of representations rather than individual experience-based representations as might be expected.

Our mixed approach has facilitated the collection of data on how LOVE prototypes specify more exhaustively the mode of synthesis and the cognitive mapping under which these may occur. As such, it contributes to the clarification of the semantic processes involved in the structure of passwords and opens new avenues for further research. Future related research may foreground not only the semantic and philosophical distinction existing between concepts and properties but also the answers that the conceptual spaces framework can contribute to various theories of mind and social cognitive and behavioural processes. As our results indicate that language users' minds are surprisingly compatible when minds cognitively meet on common referents (showcasing LOVE in our study), we have enough grounds to believe that there is more promising room for the examination of the semantic processes and mechanisms underlying the composition of expressions. Further research can be also extended to other categories (emotional or otherwise) that possess a higher degree of universality and pose categorizing issues emerging from their social, cultural, perceptual attributes, and psychological relevance.



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KREIRANJE LOZINKI: IZMEĐU PROTOTIPNE PERPEKTIVE I KONCEPTUALNOG PROSTORA LJUBAVI

Primjenjujući instrumente teorije prototipova, u ovoj se studiji nastoji utvrditi postoji li pri kreiranju lozinki zajednički kognitivni uzorak na temelju kojega se kategorizira pojam LJUBAVI. Analitičku okosnicu rada čini kombinacija metode slobodnog nabiranja, kojom se izlučilo ključne informacije o riječima koje se općenito vezuju uz pojam i analize rezultata rangiranja prototipnosti. Dobiveni su rezultati uspoređeni s bazom nasumično odabranih lozinki kako bi se utvrdile semantičke asocijacije pojma LJUBAVI i razjasnili semantički procesi u strukturi lozinki. Rezultati ukazuju na to da u kategorizaciji LJUBAVI korisnici lozinki imaju sukladne konceptualne prikaze koji omogućuju susret umova. Zaključak je studije da LJUBAV djeluje kao svojevrsno sidršte u mentalnoj obradi dotičnog KONCEPTUALNOG PROSTORA te da ga u korisnika lozinki obilježava idealiziran oblik prikaza, a ne, protivno očekivanjima, prikazi temeljeni na pojedinačnim iskustvima. Naš je analitički pristup omogućio prikupljanje podataka o tome na koji način prototipovi LJUBAVI elaboriraju način sintetiziranja i kognitivnih preslikavanja unutar kojih se oni mogu pojaviti.

Ključne riječi: LJUBAV; prototip; lozinke; KONCEPTUALNI PROSTOR; preslikavanje.