UNIVERSITÀ DEGLI STUDI DI TRENTO
Dipartimento di Scienze della Cognizione e della Formazione

Dottorato in Scienze della Cognizione e della Formazione
Ciclo XXII

Computational Production of Affect-Based Verbal Humorous Expressions

a PhD Dissertation by

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Rovereto, December, 10, 2009

"The scientist will set upon the problem like a starved chihuahua on a pork chop."

Anonymous

Abstract

In this work we provided a contribution in the specific context of verbal humor generation, focused on computational creation of humorous texts. The goal consisted of the design and implementation of a tool for the automatic generation of short humorous expressions. We focused on humorous puns generated through the variation of familiar expressions, performed via lexical substitution. Phonetic and semantic features are employed to select the appropriate substitution. We have chosen a corpus-based approach, in line with a tendency prevailing in the computational linguistics field. A number of textual corpora and dictionaries were employed. We have developed some of these resources (WordNet-Affect and Affective-Weight) in an early stage of the research. The system can be used as a testbed for the empirical investigation of various aspects of verbal humor. More specifically, it can be used to study the correlation between linguistic parameters of humorous expressions and appraisal dimensions that are part of the cognitive process of humor understanding. In the last phase of the work, we developed two exploratory applications: a prototype was developed as a first component of a system in which task-oriented assistance and humorous feedback can be integrated to achieve frustration reduction. The other application developed is a tool for the collaborative creation of puns. In this system, the pun generator is integrated with a graphical user interface based on a dynamic graph, helping the exploration of different creative solutions.

Acknowledgements

This thesis could not have been completed without the precious support of many people.

First of all, I would like to thank my supervisors, Dr. Carlo Strapparava and Dr. Oliviero Stock. They have provided me all these years with their support, patience, friendship, and enthusiasm.

A special thanks goes to Prof. Anton Nijholt, who hosted me at the University of Twente. His advice and exchange of ideas was vital for giving shape to this research. He is living proof that it is possible to be a researcher and have fun . . . especially if the topic of the research is "entertainment".

I would also like to thank Prof. Helmut Prendinger for having given me the opportunity to experience a very stimulating period of research at the National Institute of Informatics, Tokyo, and Prof. Mitsuru Ishizuka and for his interest in my ideas and the opportunity to present them at Tokyo University.

A special thank you to Prof. Andrew Ortony, whose destiny seems to be to run up against me multiple times. He has had the patience to explain a single joke to me for three days before I was able to finally understand it. I have still much to learn from him about emotions and humor. A special thanks to Prof. Graeme Ritchie for an exchange of ideas that has had a strong influence on my research, to Prof. Prof. Rieks op den Akker for the sharp remarks, and to Prof. Jessica Milner Davis for having taught me the subtle connection between humor and style.

A sincere thank you to my colleagues and friends during my PhD, who shared with me emotions and mutual support. For me they have been like a family over the last three years.

I would especially like to thank all my colleagues and friends of the group of Human Computer Technology, at FBK. Their presence was very important for me. Thanks also to all my friendly colleagues at the Digital

Content and Media Sciences Research Division of the National Institute of Informatics, Tokyo, and at the Human Media Interaction research group of the University of Twente. They made my research period an exciting experience.

Finally, the greatest thanks of all to my parents who supported me in every moment with care and affection.

Contents

A Tiziana Bascelli e Tiziano Noselli, senza i quali quest'avventura non sarebbe mai iniziata.

Chapter 1

Introduction

Language can induce emotions. The connotation of words and the tone of one's voice express emotions and attitudes that have an impact on the recipient. Persuasive messages are delivered to induce beliefs and desires and promote certain behaviors. Good or bad news can provoke positive or negative affective states. Humorous language is a special case of emotive communication whose effects are mirth and laughter. Our culture has developed more and more sophisticated strategies for intentionally inducing laughter. Language provides a way to create expectations and then later to violate them, and to force people to switch from a familiar induced interpretation to a different unexpected one. Intentionally created linguistic ambiguities, imperfections, and errors are employed to excite and amaze the recipient, and to provoke smile, good mood, or laughter.

Humor is a multi-disciplinary field of research. People have been working on humor in many fields of research such as literature and philosophy, linguistics and sociology, psychology and neurosciences. More recently it has become a topic of study in the field of computer science.

Computational humor is a research area lying at the intersection between computational linguistics and artificial intelligence. It mainly aims at the implementation of tools able to generate and recognize humor automatically, but also can contribute to the study of humor through computational simulations. Prototypes developed so far are very limited, if compared to the human capability to understand and produce humor. In most cases, they are able to simulate very limited aspects of humorous behavior, for example generating short jokes or puns based on wordplays. They are generally based on a number of ad hoc rules performing simple linguistic manipulations.

In this work we provide a contribution to overcome some of these limitations. The context is that of *verbal humor generation*, focused on computational creation of short humorous texts. The aims of this research are the following:

1. **Development of an automatic pun generator.** Puns are short expressions created through wordplays exploiting different forms of lexical ambiguity (e.g. a word with multiple meanings, or two words with similar sound), for humorous effect. More specifically, we focus on humorous puns generated through alteration of familiar expression (e.g. proverbs, movie titles, or idioms). The variation is performed via lexical substitution of one word in the original expression. There are several advantages in reducing the problem of pun generation to a problem of lexical selection. On one hand, this pun generation model is sufficiently simple to be computationally tractable. On the other hand, the model is sufficiently complex to allow us to shed some light on some forms of humor, especially on elements in the connection between language and cognitive processing. As indicated below we have chosen a corpus-based approach, in line with a tendency prevailing in the computational linguistics field. The approach results in some nice properties especially for identifying the abstract level of the process.

2. **Investigation of possible experimental employment.**

   A graphical tool was created for facilitating the interactive work with the pun generator. The tool can be used for interactively exploring strategies, and can help in the design of experiments. The resulting system can provide a test bed for the study of human processing of verbal humor. Puns can be randomly generated according to fixed values of lexical parameters and thus be treated as stimuli inducing a corresponding emotional response. Part of this preliminary investigation is an explorative, initial, study with human judges on the role and different weight of phonetic and semantic constraints for the humorous power of puns. We have just considered taboo words (therefore limiting the fuzziness of this component), and phonetic distance, defined as a specification of the Levenshtein algorithm (Levenshtein, 1966).

3. **Exploration of possible applicative uses of the system.**

A key aspect of the work lies in the connections between humor and emotion, at two different levels: 1) general design, which reflect some aspects of the affective nature of humor (i.e. humor as a way to induce emotions), and 2) implementation of specific humorous strategies employing the affective expressivity of text. These two aspects are quite independent, and exploited in separate ways.

As claimed by Graeme Ritchie in a recent assessment of computational humor (Ritchie, 2009), the main limitation of these systems is that they are not based on models from theories of humor. A possible reason is that at present there is not a coherent and generally accepted theory of humor according to which the computational system can be designed. In our approach, we considered not only theories of humor but also theories of emotion.

As far as the latter aspect is conceived, the *Appraisal Theory of Emotions* (Schachter and Singer, 1962; Scherer et al., 2001) is for us the most suitable resource. According to this theory, the elicitation of emotions occurs as a process of cognitive evaluation (*appraisal*) of a set of perceptual stimuli (*appraisal dimensions*).

In the more specific context of *verbal humor generation*, focused on computational creation of humorous texts, the affective approach characterizes the development of the system in the following way:

1. Text generation is performed according to parameters corresponding to different characteristics of the text.

2. The parameters of text generation can be connected to independent appraisal dimensions. For example, some parameters employed in the generation of ambiguous humorous texts (e.g. through selection of words with multiple meanings) can be correlated to the perception of incongruity. According to incongruity-theories of humor, incongruity perception is one of the factors for the induction of humorous effect. In the framework of the Appraisal Theory of Emotions, incongruity perception can be interpreted as an appraisal dimension in the elicitation of mirth. Thus, a computational humor generator in which the generation of ambiguity is identified by a specific parameter allows us to study the role of incongruity in the process of humor understanding.

The second element of our affective approach to computational humor generation consists of the assumption that the affective expressivity of language can be employed as a specific humorous strategy. For example, the affective meaning of words and their polarity can be employed to perform effects of exaggeration or semantic opposition yielding ironic humorous communication.

In the implementation of our system we developed specific strategies based on affect recognition in words. To this purpose, we take advantage of techniques for lexical affect sensing, a recent area of computational linguistics aimed at automatic extraction of affective information from texts. Using these resources we can manage, to some extent, the affective connotation of words and the identification of positive or negative polarity. In this way, we can generate text containing either exaggeration or irony based on semantic opposition, and can then use this information to produce humor.

The resources employed in our system take advantage of the current trend in the area of computational linguistics, following which the rule-based approach was gradually substituted by approaches based on statistical analysis of textual corpora (i.e. *corpus-based* techniques).

The motivations for this paradigm shift have been mainly the following needs, which normally could not be satisfied by previous systems:

- The necessity of portability (adapting quickly systems to different domains), and of robustness, i.e. yielding results, however limited, in most circumstances.
- Coping with the "pressure", imposed mainly by American funding agencies, for "quantifying" improvements in research systems, within pre-defined, short term competitions. These competitions were imported from the tradition of the speech processing community.

The opportunity was provided by important developments that took place since the beginning of the Nineties:

1. The availability of a large quantity of digital texts, made available to all through the web. In practice the advent of the computer makes all the text production in the world be in digital form, and scanning and library programs make digital a very large portion of what was written since the invention of writing.
2. The consolidation of automatic learning techniques, some of which particularly suited for text processing.

A number of corpus-based techniques have appeared, in general characterized by a more shallow, but robust approach to language, and a large attention to aspects like correlations, co-locations and in general discovery of properties of texts that sometime are not clearly visible by a formalist.

As said, for humor generation, most of the very few implemented systems are still based on the use of the old rule-based approach. Following that approach, mostly, humor generators could be very limited in the knowledge they make use of. Mostly, pattern-matching rules were interfaced with hand-made dictionaries expressing limited information. The interfacing of large-scale lexical knowledge bases such as WordNet (Fellbaum, 1998) was an improvement that did not overcome the problem, because the source of knowledge was still hand-made and with a frozen structure .

Present NLP approaches often tend to be substantially different. It is clear that the task is limited and there is no ambition of modeling sophisticated knowledge. On the other hand it is based on real use of language and on a learning process that the system can realize. Resources on which the learning is based can be under control, as in the case of fixed, well balanced corpora such as the British National Corpus (BNC-Consortium, 2000), or open, without control, like the Web itself.

From the sociolinguistic point of view a corpus can be seen as the expression of a certain social group in a certain period of time, in relation to specific genres or themes. Adopting one specific corpus can produce different results than adopting another.

From the point of view of humor generation both robustness (in particular independence from a domain) and adaptivity to a specific group are very important features.

A challenge is to provide the humor generator with a form of creative capability. The intrinsic lexical richness allows the system to explore a not previously described semantic domain and generate a number of humorous lexical substitutions, provided appropriate strategies are defined. This is exactly our level of modeling: while the technical tools are based on the concept of lexical (phonetic and semantic), the overall use of the techniques can be combined in diverse ways at the meta-level. This modeling is realized by the system and the latters creativity is then an effect of the specific dynamic choices that the system realizes according to these strategies while discovering distances in the corpus at hand.

As will be mentioned in section 3.4.2, innovation is "optimal" when it maintains a connection with something recognized as familiar. "Variation of familiar expressions" reflects this view: innovation must be circumscribed to be effective; only then the evocative power of the variation is strong. As for humor, for instance in the case of irony, the effect is better obtained if there are strong opposition elements at the semantic level and minimal perceivable changes in the form. The material in contrast with the substituted part will evoke a whole dimension that under certain conditions provokes laughter.

All the machinery has to be flexible. For instance the concepts evoked by some proper noun (e.g. names of famous persons or cities) can change over the time, as evident if the corpus is one of regularly updated newspapers. As an example take the noun phrase “twin towers”: it has changed its evocative power over time, and the association with the noun “airplane” has become stronger after September 11, 2001.

As indicated above, one of the key aspects in our system is the use of affective connotations as an element in the expression variation. This is realized through the same technical tools of distance-finding, and appropriate definition of the process at the meta-level. In the case of affect the change over time (or with different social groups) of the affective connotation is obvious. In the case of the example above, after September 11, “twin towers” acquired an an affectively negative connotation.

Sensing of affective connotation of words in the system is taken care of by a function (called Affective-Weight and described in section 4.3) which allows to extract, to some extent, the polarity and the intensity of the affective meaning evoked by the word. It is employed to perform ironic effects: polarity can be used to achieve semantic opposition, and intensity can be used to achieve some forms of exaggeration. For example, it can constraint the system to apply word substitutions in which the original word is positive and the replacement word is negative independently from the specific domain taken into account.

To sum up, the key characteristics of the system developed in this work are the following:

1. **Corpus-based approach.** It allows us to collect a large amount of associative knowledge. This information is employed to perform a

dynamic exploration of semantic domains and, thus, to select the appropriate words for the creative manipulation of textual expressions.

2. **Meta-level semantic constraints.** A function of lexical affect sensing is employed to manage specific domain-independent and affective features such as emotional polarity.

3. **Measure of variables for humor studies.** The operative definition of numerical variables (i.e. phonetic distance and semantic similarity) makes the systems useful for experimentation on the cognitive processing of humor. The possibility to generate random expressions according to a fixed range of phonetic distance and semantic constraints can be usefully employed for the investigation of the relationship between linguistic parameters and cognitive appraisal dimensions such as incongruity perception.

Finally, we would like to emphasize the applied dimension. The role of humor can be important in future system which must be adaptive to the user and the context. We consider two application domains. One is traditional, i.e. the use of simple forms of humor, like irony, in advertisements. A flexible system oriented to advertising can help produce many different ads, possibly taking into account different social groups, or situations. The second application is in a task-oriented activity like learning, where the affective aspect of the activity may benefit from adaptive humorous expressions to release the tension.

1.1 Thesis outline

Chapter 2 reviews the literature relevant to this research. Chapter 3 describes the theoretical framework supporting the design of the system. In Chapter 4, the approach adopted for the generation of humorous puns is presented and the resources required for its implementation are assessed. Chapter 5 discusses the possible use of the tool for empirical investigation on humor and describes a preliminary exploratory study carried out, focusing on one dynamic component, the phonetic one, and keeping the semantic specification of substituting words connotated in a fixed way, non correlated to input, so to limit fuzziness. In Chapter 6 two exploratory tools are presented. The first one is an interactive version of the pun generator. The second one is an interactive planner in which task decomposition and humorous remarks can be integrated for achieving frustration reduction. In the final part (Chapter 7)conclusions are drawn and future prospects are given.

Chapter 2

Background

2.1 Introduction

2.2 General thoughts on humor

While humor is generally considered merely a way to induce amusement, it provides an important way to influence the mental state of people to improve their activity. Even though reproducing humor is a very complex task, it is realistic to model some types of humor production and to aim at implementing this capability in computational systems. There are several elements that make humor important from a cognitive point of view.

Humor is a powerful generator of emotions. As such, it has an impact on people's psychological state, directs their attention (Kitayama and Niedenthal, 1994), influences the processes of memorization (Kahneman, 1973) and decision-making (Isen, 1993), and creates desires. Emotions are an extraordinary instrument for motivation and persuasion because those who are capable of transmitting and evoking them have the power to influence other people's opinions and behaviour. Humor, therefore, allows for conscious and constructive use of the affective states generated by it. Affective induction through verbal language is particularly interesting; and humor is one of the most effective ways of achieving it. Purposeful use of humorous techniques enables us to induce positive emotions and mood and to exploit their cognitive and behavioural effects. For example, the persuasive effect of humor and emotions is well known and widely employed in advertising. Advertisements have to be both short and meaningful, to be able to convey information and emotions at the same time.

Humor acts not only upon emotions, but also on human beliefs. A joke plays on the beliefs and expectations of the hearer. By violating those expectations, it causes surprise and then hilarity. Jesting with beliefs and opinions, humor induces irony and helps people to not take themselves too seriously. Sometimes simple wit can sweep away a negative outlook that places limits on people desires and abilities.

Humor encourages creativity as well. The change of perspective caused by humorous situations induces new ways of interpreting the same event. By stripping away clichés and commonplaces, and stressing their inconsistency, people become more open to new ideas and points of view. Machines equipped with humorous capabilities will be able to play an active role in inducing users' emotions and beliefs, and in providing motivational support.

2.3 Theories of humor

Humor is a multi-disciplinary field of research. People have been working on humor in many fields of research such as literature and philosophy, linguistics and sociology, psychology and neurosciences. There are hundreds theories of humor (Schmidt and Williams, 1971), each describing this topic from a different point of view. In recent years the study of humor has acquired a scientific characterization, and classical theories can provide a basis on which to develop a modern scientific theory.

In the conventional literature on theories on humor there is a division according to three types:

- Superiority Theory

- Relief Theory
- Incongruity Theory

Even if the perspective of each theory is different, there is a need to have an integrated approach to the study of different aspects of humor, and the context of cognitive sciences seems to be the most appropriate.

2.3.1 Superiority theory

The assumption of superiority theory is that we laugh about the misfortunes of others; it reflects our own superiority. This theory can be found in the work of Plato, Aristotle, and Hobbes. Plato suggests that humor is a kind of malice towards those who are considered relatively powerless. Hobbes further explains that humans are in a constant competition with each other, looking for the shortcomings of other persons. He considers laughter as an expression of a sudden realisation that we are better than others.

Although this theory may seem old-fashioned, Charles Gruner (1997) reformulated this theory as the *Superiority Theory of Humor*. His theory contains a three-part thesis:

1. Every humorous situation has a winner and a loser;
2. Incongruity is always present in a humorous situation;
3. Humor requires an element of surprise.

The first part of this thesis contains the idea of *superiority*. The assumption that all humor has a winner and a loser is based on human nature. Through history humans have used humor to "compete"with other persons, making them the target of their humorous comment. The "winner" is the one who successfully makes fun of the "loser". This theory can explain the source of laughter in some humorous television programs, like sitcoms and talk shows.

2.3.2 Relief theory

Relief Theory has a psychoanalytic or psycho-physiological nature. Freud (1905) proposed a theory based on how laughter can release tension and "psychic energy". This energy continuously builds up within the human body, has no further use and therefore has to be released. This release is spontaneous and expresses itself in laughter. Freud explains that the psychic energy in our body is built as an aid for suppressing feelings in taboo areas, like sex or death. When this energy is released we experience laughter, not only because of the release of this energy, but also because these taboo thoughts are being entertained. A more conventional version of the Relief Theory is that we experience a pleasant sensation when humor replaces negative feelings like pain or sadness.

2.3.3 Incongruity theory

The incongruity theory is the most influential approach to the study of humor and laughter. One of the first definitions of incongruity is provided by Beattie (1971): "Laugher arises from the view of two or more inconsistent, unsuitable, or incongruous parts or circumstances, considered as united in one complex object or assemblage, or as acquiring a sort of mutual relation from the peculiar manner in which the mind takes notice of them". Other historically important treatments are by Schopenhauer (1883) and Freud (1905). One of the most interesting presentations of the notion of incongruity came from Koestler (1964), who defined 'bisociation':"[...] the perceiving of a situation or idea, L, in two self-consistent but habitually incompatible frames of reference, M1 and M2." Raskin (1985) formulated the incongruity concept in terms of 'scripts', where a script is a structured configuration of knowledge about some stereotyped or familiar situation or activity. This has been developed further, into the General Theory of Verbal Humor (Attardo and Raskin, 1991). When jokes are examined in the light of the incongruity theory, two objects in the joke are presented through a single concept, or 'frame'. The concept becomes applied to both objects and the objects become similar. As the joke progresses, it becomes apparent that this concept only applies to one of the two objects and thus the difference between the objects or their concepts becomes apparent. This is what is called *incongruity*. According to this model, humorous text has a semantic incompatibility (e.g., a inconsistency inside the same interpretation, or a conflict between two different interpretations). When this incompatibility is perceived, there is an incongruity that generates a humorous effect. According to other versions of this theory (*incongruity resolution theories*), the humorous effect is not caused by incongruity, but rather by its resolution (e.g., when a new consistent interpretation is found, or when one of two interpretations is chosen). Incongruity theory focuses on the element of surprise. It states that humor is created out of a conflict between what is expected and what actually occurs in the joke.

2.3.4 Reversal theory

Although it is widely agreed that humor is a playful activity, and that laugher can occur in both children and chimpanzees in playful contexts, only a small number of scholars have claimed that the connection between humor and play. Max Eastman (1936) put in evidence distinction between "playful" and "serious". More recently, other authors such as William Fry (1963) have described humor as a form of play. Apter and Smith (1977) performed a more general investigation of this idea, called *reversal theory*. For them, play is an attitude, or a state of mind, called the *paratelic* state, to distinguish it from the *telic* (goal-directed) state characterizing serious activities.

The basic idea underlying reversal theory is that to experience humor, we need to be in a paratelic state. As a possible consequence, it is observable that humorous stimuli have to include metacommunicative elements to signal the playful context. The induction of the paratelic state would explain why the opposition described in incongruity theories, or the despicable traits shown in superiority theories, are able to generate amusement instead confusion or anger. From the linguistic point of view, playful context can be induced through pragmatic cues characterizing the illocutionary force of humorous messages (Kotthoff, 2006).

2.3.5 Pattern recognition theory

A recent explanation of humor in terms of a primitive cognitive mechanism was proposed by the science writer Alastair Clark (2008). According to this idea, humorous response is the effect of the recognition of a perceptual pattern. Even this theory presents strong limitations (e.g. there are many examples of pattern recognition that are provoke humorous effect), it suggests focusing on evolutionary reasons for the existence of cognitive processes rewarded with mirth and laughter.

2.3.6 Limitations of current knowledge

At present, there is no general theory of humor that integrates the various aspects put forward by these different theories, even if there are efforts towards this direction. This research will not be able to tackle this general problem either. Yet it will be important to have an integrated perspective of three main levels of description: linguistic, cognitive, and affective. It is useful to distinguish and connect notions from each of these levels. For instance, if we claim that "the ambiguity of an expression induces a state of surprise and corresponds to an increase of arousal", there is a connection between linguistic (*ambiguity*), cognitive (*surprise*) and affective (*arousal*) notions.

2.3.7 Humor and neuroimaging

Recent scientific results on the distinction and correlation between cognitive and affective aspects of humor recognition can be found in cognitive neuroscience. In particular, there are a number of experiments of functional neuroimaging aimed at identifying neural correlates of humor comprehension ("getting the joke") and appreciation (the affective experience of mirth). Generally the framework within which neuroimaging studies have been interpreted is incongruity-resolution theory. These results were compared to studies on patients with brain lesions, leading in some cases to different outcomes, but in general the cognitive model has been validated (for a complete review, see (Wild et al., 2003).

Illustrative of the neuroimaging approach to humor are experiments by Mobbs et al. (2003) and Bartolo et al. (2006), based on event-related functional MRI (efMRI) study of humor comprehension. Both studies aimed at measuring hemodynamic increases in regions associated with cartoons considered to be funny. The results are coherent with previous similar experiments, and allow us to identity different clusters of brain areas with a significant BOLD signal, corresponding to the cognitive-affective components of humor comprehension.

Coulson and Williams (2005) investigated humor with healthy adults using event-related potentials (ERPs). The N400 is an ERP component that is elicited by semantically anomalous information. Derks et al. (1997) found that jokes that did not elicit laughter showed no evidence of a N400 while those that elicited laughter showed a negative wave at about 400ms presumably representing the perception of incongruity.

Studies investigating physiological arousal and humor have indicated that arousal is necessary for the experience of humor. This suggests that the appreciation of humor may require the integration of cognitive and affective information.

2.4 Humor and emotion

As described in the previous chapter, humor theories can be classified as a number of different types. In each type different aspects of humor are explored and different questions are examined: *What is humor? What is its function? How is it processed? How is humor connected to different causal events and to observable behavioral and physiological responses?*

Each of them emphasizes different elements as key factors characterizing humor (e.g. incongruity perception, sense of superiority over the others, arousal level variation, etc.). More recently, there has been the need to consider a unified approach in which elements from each theory are taken in account in order to build an integrated description of humorous phenomena. In this chapter, we will try to isolate different aspects of humor and show a possible integrated view emerging from recent studies.

2.4.1 Components of humor

A good introduction to an integrated view of humor is presented by Martin (2007). In this survey there is a clear distinction between early research (including most classical theories of humor, as described in the previous chapter of this thesis) and recent research, in which results from experimental psychology and neuroscience contributes to the emergence of a new consistent framework. Early research focused on four main elements: (1) the social context, (2) the cognitive-perceptual process, (3) the vocal-behavioral expression of laughter, and (4) the emotional response.

2.4.1.1 Social context

Humor is a social phenomenon. We generally laugh "with others" and/or "at others" (Martin and Kuiper, 1999; Provine and Fischer, 1989). Sometimes we laugh when we are alone (e.g. watching a comedy show on television, reading a humorous book, or remembering a funny personal experience), but in these cases we respond to some represented character or remembered people. The main theories based on social contexts are superiority/disparagement theories and reversal theory. The former emphasizes the pleasurable feelings arising from the overturning of social roles and perceiving someone as mean or despicable. The latter presents humor as a sophisticated form of play, which is a fundamentally social activity.

2.4.1.2 Cognitive-perceptual processes

Besides the social context, specific types of cognitive processes characterize humor. The perception of a humorous stimulus (e.g. a joke, a witticism, or a situation) is based on underlying processing of meanings that are appraised as funny. What are the characteristics of a stimulus that cause us to perceive it to be humorous? Most scholars agree on the fact that, in all forms of humor, there are two fundamental elements. One is the presence of some incongruous, unexpected, and surprising perception. The other one is some aspect that causes us to appraise this surprising element as funny. In other words, the two key elements of humor seem to be incongruity and playfulness, which Gervais and Wilson (2005) called “non-serious social incongruity”. *Incongruity* and *incongruity-resolution theories* are mainly focused on cognitive and linguistic aspects of humor, and mainly the first of these two dimensions. Unfortunately, these theories do not explain what characterizes incongruity as amazing and what are the relationship between cognitive processes and the affective response of humor appreciation.

2.4.1.3 Affective response

Humor induces in humans a particular experience of amusement. At present there is no agreement about the word to denote this emotion. According to (Martin, 2007), the term ’mirth’ seems to be the most appropriate. The types of theories that treat the emotional aspects of humor are *superiority theories* and *arousal theories*. In the former, the pleasurable humorous feeling arises from the disparagement toward some target character or category of people. In the latter, the humorous response essentially consists of variations of arousal, corresponding to the activation level of the nervous autonomic system.

2.4.1.4 Laughter

Laughher is another important component of humor. The intensity of humorous effect is correlated to different rates in the vocal-behavioral response, from a faint smile, for low intensity, to a loud guffaw for highest intensity. Laughter is a social behavior. If there are not other people to communicate with, we do not generally have a need to laugh. There are at least three possible functions attributed to humans as well as apes: (1) signaling to others that one is engaging in play (van Hooff, 1972), (2) inducing the playful state (Owren and Bachorowski, 2003), and/or (3) motivating others either towards desirable behaviors ("laughing with") or against negative behaviors ("laughing at") (Shiota et al., 2004). *Reversal theory* is the most suitable way to explain the function of laughter as a way to express the non-serious attitude.

2.4.2 Emotion as unifying framework

In this work, we choose to emphasize the affective character of humor. It is reasonable to view emotional description as the framework underlying the different theoretical approaches and connecting the component of humor described above. Humor is not only characterized by a specific emotion (mirth), but is essentially a form of emotional induction. Like other emotions, mirth is characterized by a set of eliciting stimuli intentionally provoked by the speaker/writer (e.g. incongruous meanings, surprising events, evocation of despicable characters, and playful context), an evaluation process involving them, and a number of possible responses, the most typical being laughter. Then all the components of humor mentioned above (with the related theories) can be integrated with the affective description.

More specifically, humor can be described in the context of appraisal theories of emotions (Arnold, 1960; Lazarus, 1966; Smith and Lazarus, 1990), according to which emotions arise from the appraisal of certain characteristics of events. Particularly interesting are modular appraisal theories (Frijda, 1986; Scherer, 2001). In this framework, the two basic dimensions of humor (*incongruity* and *playfulness*) can be treated as independent appraisal components for the elicitation of mirth.

2.4.3 Incongruity and arousal

One challenging issue in the affective approach to humor studies is the investigation of the connection between incongruity and arousal. Rothbart (1977) argues that arousal and incongruity theories are not incompatible but instead describe humor from two different points of view. According to (Chapman and Foot, 1996), the cognitive experiences of incongruity and resolution have physiological correlates in terms of arousal fluctuations in arousal.

It is thus natural to ask whether humor is the effect of arousal itself or is instead relief from it. Surprisingly, physiological measures of arousal have shown that experimental subjects remained aroused after the punch-line of a joke, while they were laughing (Rothbart, 1977). This result supports the claim that humor arises from arousal rather than from relief (Palmer, 1994). In other words, incongruity can lead to an increase in arousal, which according to Rothbart, is pleasurable if it is perceived in a playful situation.

Chapter 3

Theoretical framework

3.1 Introduction

Automated humor production in general is a very difficult task. In the short term it is realistic to focus on a simple type of texts, in which at least part of the humorous power is connected to simple manipulations of the superficial linguistic structure. For this reason, also earlier computational humor focused mainly on short textual expressions, such as puns. For the purpose of this research, we are interested in studying a pun generator in order to advance limitations of past prototypes.

Puns are short expressions produced creatively for humorous or rhetorical effect (Attardo, 1994; Hempelmann, 2003). Typical characteristic of puns is their shortness. Unlike jokes, in particular, they have no narrative structure. At the same time, puns have a particular linguistic structure that allows them to express creativity and humor. They may exhibit symmetries and wordplays that make them surprising and aesthetically pleasant. Generally they have some incongruity that, combined with pleasantness, induces amusement. There are a number of pun types, according to length (one-line puns, punning riddles), type of ambiguity (syntactic ambiguity, focus ambiguity, scope ambiguity, pronoun ambiguity), type of similarity (paranomasic puns, syntagmatic puns, orthographic puns), modality (textual puns, visual puns), or context (self-contained textual puns, contextual puns).

Examples of English puns are:

1. "Why do birds fly south in winter?" "Because it's too far to walk" (punning riddle)
2. Some South American stamps are un-Bolivia-ble (one-line self-contained pun)
3. It is better to be looked over than to be overlooked (syntagmatic pun)

Examples of Italian puns are:

1. Lo sfigato: "la vita è jella". (comic definition, playing on a famous movie title)
2. Qual è il colmo per un orologiaio? Avere la figlia sveglia.
3. "Al di là del pepe e del sale", "panna dei miracoli", "il cacio della nonna a bagno" (references to food, playing on movie titles)

All types of puns exhibit ambiguity, generally at the lexical level. In some definitions, the term "pun" refers to this interference between different meanings. Different kinds of ambiguity are possible. For example, it is possible to play on different meanings of the same word (*polysemy*), on two different words with the same spelling (*homophony*), or on two similar-sounding words (*heterophony*). In the latter case, this use of word is called *paronomasia*, and these types of puns are called *paronomasic* (or *heterophonic*, or *imperfect*) *puns* (Hempelmann, 2003).

These characteristics of puns make them particularly suitable for use in computational humor research. In fact since they are quite simple (from the linguistic point of view), in principle they can be produced computationally. Furthermore they are sufficiently complex to be able to express different types of humor (incongruity resolution, nonsense, sexual humor, etc.).

3.2 Computational humor

In the context of computer science (or Artificial Intelligence), humor research aims at modelling humor in a computationally tractable way. To date there are only a limited number of research contributions resulting in the construction of computational humor prototypes. A good review of the field can be found in (Ritchie, 2001).

Almost all these approaches are based on incongruity theory at various levels of refinement (Koestler, 1964; Raskin, 1985; Attardo, 1994; Krikmann, 2005). Minsky (1981) adopted and refined Freud's notion that humor is a way of bypassing our mental "censors" which control inappropriate thoughts and feelings (Freud, 1905).

One of the first attempts that deals with computational humor generation is the work described in (Binsted and Ritchie, 1997), where a formal model of semantic and syntactic regularities was devised, underlying some types of puns (punning riddles). A punning riddle is a question-answer riddle that uses phonological ambiguity. The three main strategies used to create phonological ambiguity are syllable substitution, word substitution and metathesis.

Syllable substitution is a strategy where a syllable in a word is confused with a similar or identical sounding word. An example of syllable substitution is shown in the following joke: "What do shortsighted ghosts wear? Spooktacles" (Webb, 1978). *Word substitution* is the strategy of confusing an entire word with another similar or identical-sounding word. An example of a joke employing word substitution is: "How do you make gold soup? Put fourteen carrots in it" (Webb, 1978). *Metathesis* is a strategy very different from syllable or word substitution. It uses the reversal of sounds and words to suggest a similarity in meaning between two semantically distinct phrases. An example is "What is the difference between a torn flag and a postage stamp? One's a tattered banner and the other's a battered tanner." (Binsted and Ritchie, 1997). Punning riddles based on all three of the strategies are suitable for computer generation. Ritchie and

Binsted focussed on word substitution-based punning riddles, as lists of homophones (i.e. phonetically identical words) were already readily available. In order to describe a punning riddle, two sorts of symbolic descriptions have to be used: *schema* and *template*. A schema stipulates a set of relations that must hold between the lexemes used to build a joke. A template indicates the information necessary to turn a schema and lexemes into a piece of text. It contains fixed segments of text that are to be used and syntactic details of how lexemes have to be expressed. In (Binsted and Ritchie, 1997), this model was then exploited to implement a system called JAPE, able to automatically generate amusing puns.

In one recent work, Stark et al. (2005) proposed the automatic production of funny and appropriate punchlines at the end of short jokes. The authors present a model that describes the relationship between the connector (part of the set-up) and the disjunctor (the punchline). In particular they have implemented this model in a system which, given a joke set-up, can select the best disjunctor from a list of alternatives.

Another project was HAHAcronym (Stock and Strapparava, 2003), whose goal was to develop a system to automatically generate humorous versions of existing acronyms, or else to produce a new funny acronym constrained to be a valid vocabulary word, starting with concepts provided by the user. The humorous effect was achieved mainly on the basis of incongruity. Another interesting work concerned with generation of humor was based on the ambiguity of referring expressions (mainly pronouns) (Nijholt, 2006; Tinholt, 2007).

Humor recognition has received less attention. The application of text categorization techniques to humor recognition has been investigated in (Mihalcea and Strapparava, 2006). In particular the authors show that classification techniques are a viable approach for distinguishing between humorous and non-humorous text, through experiments performed on very large data sets. They restrict their investigation to the type of humor found in one-liners. A one-liner is a short sentence with comic effects and a peculiar linguistic structure: simple syntax, deliberate use of rhetoric devices (e.g. alliteration, rhyme), and frequent use of creative language constructions meant to attract the readers' attention. While longer jokes can have a relatively complex narrative structure, a one-liner must produce the humorous effect "in one shot", with very few words. The humor-recognition problem is formulated as a traditional classification task, feeding positive (humorous) and negative (non humorous) examples to a set of automatic classifiers. The humorous data set consisted of a corpus of 16,000 one-liners collected from the Web using an automatic bootstrapping process. The non-humorous data were selected such that it is structurally and stylistically similar to the one-liners. In particular, four different corpora were selected, each composed of 16,000 sentences: (1) Reuters news titles (Lewis et al., 2004); (2) proverbs; (3) sentences picked from the British National Corpus (BNC-Consortium, 2000); and (4) commonsense statements from the Open Mind Common Sense (OMCS) corpus (Singh, 2002). The features taken into account were both content-based features, usually considered in traditional text categorization tasks, and specific stylistic features, such as alliteration, presence of antonymy and adult slang. The classification results were very encouraging.

Other related work is reported in (Taylor and Mazlack, 2004), focussing on a very restricted type of wordplays, namely "Knock-Knock" jokes. The goal of the study was to evaluate to what extent wordplay can be automatically identified in "Knock-Knock" jokes, and if such jokes can be reliably identified from other non-humorous texts. The algorithm is based on automatically extracted structural patterns and on heuristics that are heavily based on the peculiar structure of this particular type of joke. While wordplay recognition gave satisfactory results, the identification of jokes containing such wordplays turned out to be significantly more difficult.

Also worth mentioning is a formalization, based on a cognitive approach (the belief-desire-intention model), distinguishing between real and fictional humor (Mele, 2002). Finally Taylor and Mazlack (2005) propose a first attempt to recognize the humorous intent of short dialogs. According to the authors, computational recognition of humorous intent can be divided into two parts: recognition of a humorous text, and recognition of the intent to be humorous. The approach is based on detecting ambiguity both in the setup and in the punchline.

3.3 State of the art limitations

Automated pun generators developed so far appear very limited when compared to human performance. Evaluation studies on some of these systems, such as JAPE (Binsted et al., 1997), show that a statistically meaningful amount of the outputs of these systems are judged funny. Nevertheless evaluation conditions are very specific and, with other conditions, these results may be different. In particular, the same text may be more or less funny to different types of subjects, according to age, character, level of education, etc. (Ruch, 1998).

Another factor is the intended use for the text of the computational puns. For example, if the generated outputs are advertising headlines, it is sufficient to have a sufficiently large number of recipients that consider them funny. But if the user is a copywriter that has to select the best one, then probably most of outputs will have to be effective and inspiring so as not to waste the copywriter's time. Finally, if the same user has to test the system over time, the history of interaction may have a role and soon the user might begin to perceive the system as boring and less creative than it appeared at the beginning.

Developed systems are characterized by two elements: a set of rules (providing syntactic and semantic constraints) and resources (dictionaries, lexical databases, ontologies, or textual corpora) representing linguistic knowledge at some level.

Ritchie (2004) states that processing humorous text requires computational systems to have various other capabilities or resources, in particular a vast amount of knowledge about the real world. This implies that it is very important to access linguistic resources. Large scale resources (e.g. textual corpora) provide more richness of output and so more flexibility.

Furthermore, it is important to have mechanisms for knowledge updating (e.g. through machine learning strategies and in particular statistical information extraction from large scale textual corpora), in order to increase knowledge and make it adaptive. But these improvements still might not be sufficient to make procedures creative enough. In fact, systems are constrained to a restricted context and, even if linguistic resources allow them to produce new ways to play the same game, humans can do more. People are able to invent new games all the time and induce surprise at different levels.

In order to improve computational humor performance, a main challenge is to achieve the capability to simulate not only humorous artifacts but also the process that allows us to produce them. At present there is little overlap between theory and computer realization. Descriptive work is quite separate from the small-scale software projects of recent years and "theories of humor are rarely stated with sufficient detail or formality to allow for their implementation" (Ritchie, 2004).

3.4 Variation of familiar expressions

The system developed in this work is based on a model of humorous text and generation mechanism with two opposite characteristics. On one hand, the model has to be sufficiently simple to be computationally tractable, to take advantage of available linguistic resources, and to allow the user to easy manipulation of parameters. On the other hand, the generator has to be sufficiently complex to involve aspects that are in common with more general systems.

A specific type of humorous text is considered as the working context: simple one-line puns. They are obtained through the variation of familiar expressions (e.g., proverbs, movie titles, name of famous persons, etc.). In most cases, the variation is performed through the substitution of a word of the original expression with a different but phonetically similar word.

Examples of English puns are:

- *To write with a broken pencil is pointless.*
- *Atheism is a non-prophet organization.*
- *The dead batteries were given out free of charge.*

Example puns in Italian are:

- *Vidimare quant'è bello!* (slogan for advertising validation of bus tickets in Napoli, playing on a line of a popular Neapolitan song)
- *Nuova compagnia d'incanto popolare* (news headline on the first meeting of ministers of the new Italian government in Naples, playing on the name of a well known Neapolitan music group)
- *Ma ancora con 'sta scoria?* (on recent discussions about the use of nuclear energy in Italy)

3.4.1 Lexical substitution and incongruity-resolution

In this type of puns, it seems natural to interpret their funniness in the framework of the incongruity resolution theory. Even if there is no single accepted model for pun understanding, a possible sequence of cognitive events representing the processingof the type of puns treated in the present work, may be the following:

- If the phonetic similarity between the replacement word and the original word is sufficiently high, the familiar expression is recognized as if it were not modified. In other words, a form of temporary misinterpretation is induced.

- If the two words have sufficiently different meanings (and in particular induce two very different interpretations of the entire expression), then this semantic difference induces incongruity.
- If the new word is semantically inconsistent with the original interpretation and is consistent with the second interpretation, then the latter emerges (determining a frame shifting), and incongruity is resolved.

A final condition is that the new interpretation evokes a playful context, in order to make incongruity perceived as funny.

3.4.2 Advertising and the Optimal Innovation Hypothesis

Creative Variation of familiar expressions (proverbs, movie titles, famous citations, etc.) in an evocative way has been an effective technique in advertising for a long time (Pricken, 2002). A lot of efforts by professionals in the field go into producing ever novel catchy expressions with some element of humor. Indeed it is common of "creatives" to be recruited in pairs formed by a copywriter and an art director. They work in a creative partnership to conceive, develop and produce effective advertisement. While the copywriter is mostly responsible for the textual content of the creative product, the art director focalizes efforts on the graphical presentation of the message. Advertising messages tend to be quite short but, at the same time, rich of emotional meaning and persuasive power.

The variation of familiar expressions can be employed for the automatic generation of advertising messages. An advertising message induces in the recipient a positive (or negative) attitude toward the subject to advertise, for example through the evocation of an appropriate emotion. Another mandatory characteristic of an advertisement is its memorability. These two aspects of ads increase the probability to induce some wanted behaviors, for example the purchase of some product, the choice of a specific brand, or the click on some specific web link. In the last case, it is crucial to make the recipient curious about the subject referred by the URL. The best way to realize in an ads both attitude induction and memorability is the generation of surprise, generally based on creative constraints.

In order to develop the adopted approach for pun generation, we considered an interesting property of pleasurable creative communication was taken in account. It was called by Rachel Giora as the *optimal innovation hypothesis* (Giora, 2003). According to this assumption, when the novelty is in a complementary relation to salience (familiarity), it is "optimal" in the sense that it has an aesthetics value and "induce the most pleasing effect".

Therefore the simultaneous presence of novelty and familiarity makes the message potentially surprising, because this combination allows the recipient's mind to oscillate between what is known and what is different from usual. For this reasons, an advertising message must be original but, at the same time, connected to what is familiar (Pricken, 2002). Familiarity causes expectations, while novelty violates them, and finally surprise arises.

Moreover, a successful message should have a semantic connection with some concept of the target topic. At the same time, it has to be semantically related with some emotion of a prefixed valence (e.g. positive emotion as joy or negative emotion as fear).

3.4.3 Lexical reduction

Pun generation is reduced to a process of lexical substitution. In turn, appropriate lexical selection is performed according to a number of lexical constraints expressed as values or value ranges of lexical parameters. In other words, the choice of parameter values in the lexical selection is crucial for the quality of the pun. Lexical constraints can be classified in three different types: *morphological*, *phonetic* and *semantic*. In the next chapter the resources employed for the implementation of each of them will be described.

3.5 Latent Semantic Analysis

In order to perform humorous lexical substitutions, the system needs to explore semantic associations among words. For example, it needs to identify words of the same semantic field. A lexical substitution in which the replacement word refers to some input domain might be conducive to make fun of it. Another possibility consists of the extraction of connotative information, in order to perform the lexical replacement using words with a higher emotional expressivity (in order to achieve ironic forms of exaggeration) or with a different polarity (in order to achieve ironic effects of semantic opposition). Thus, the possibility to play with the evocative power of words is related to the capability to represent the associative knowledge. Part of this information is coded in pre-built dictionaries and thesauri (e.g. synonyms or antonyms), but it is not sufficient to produce a great number of creative associations. The reason is that associative knowledge reflected in real linguistic use is very large, changes over the time, and is partially subjective.

For these reasons, we adopted an approach focused on the statistical processing of large-scale textual corpora. The technique, called *Latent Semantic Analysis* (LSA), is based on the idea that association tendency in common sense knowledge is reflected in the linguistic use in terms of co-occurrence frequency. In other words, if two concepts are naturally associated in the mind of a community of speakers, the corresponding words occur, with high frequency, in the same texts. LSA technique can be summarized in the following points:

1. **Choice of a large-scale textual corpus.** The documents in the collection have a comparable length. In order to get a well-balanced corpus, texts are selected from different domains.

2. **Vector representation of words.** Each word is represented by a list of numerical weights and, thus, the corpus is represented by a matrix (called *occurrence matrix*). A typical example of the weighting of the elements of the matrix is the *df-itf* model (*frequency of term,*

inverse frequency of document), according to which the weight is the ratio of two frequencies. The first is the frequency of the word in the current document. The second is the frequency of the documents, containing that word, respect to all documents in corpus. For example, if two words occur in the same document with the same frequency, the weight depends on the number of documents in which they are present. And, of course, if a word occurs in a very high number of documents (e.g. articles or prepositions), its weight is very low. In this way, only words that might have a significant meaning are taken into account.

3. **Reduction of the matrix dimension.** After the construction of the occurrence matrix, LSA finds a low-rank approximation to the term-document matrix. There are two main reasons for this approximation. One is that the original term-document matrix is presumed too large for the computing resources; in this case, the approximated low rank matrix is interpreted as an approximation of the original. The second reason is that original term-document matrix is presumed "noisy": for example, anecdotal instances of terms are to be eliminated. From this point of view, the approximated matrix is interpreted as a "de-noisified" matrix (i.e. a better matrix than the original).

4. **Definition of term similarity function.** A measure of co-occurrence frequency of two words in the corpus is provided. It is called *semantic (term) similarity*. A common choice is to consider the scalar product between the corresponding two term vectors. A low value of this product corresponds to vectors with the same angle. In a normalized vector representation (i.e. all vectors have length 1), it is sufficient to say that the words are nearly in the same documents, and thus have a comparable value of co-occurrence frequency.

3.5.1 Technical details

To get a similarity space with the required characteristics, we used Latent Semantic Analysis (LSA). LSA is a corpus-based measure of semantic similarity proposed by Landauer et al. (1998). In LSA, term co-occurrences in a corpus are captured by means of a dimensionality reduction operated by a singular value decomposition (SVD) on the term-by-document matrix $\mathbf{T}$ representing the corpus.

SVD is a well-known operation in linear algebra, which can be applied to any rectangular matrix in order to find correlations among its rows and columns. In our case, SVD decomposes the term-by-document matrix $\mathbf{T}$ into three matrices $\mathbf{T} = \mathbf{U}\mathbf{\Sigma_k}\mathbf{V}^T$ where $\mathbf{\Sigma_k}$ is the diagonal $k \times k$ matrix containing the k singular values of $\mathbf{T}$, $\sigma_1 \geq \sigma_2 \geq \ldots \geq \sigma_k$, and $\mathbf{U}$ and $\mathbf{V}$ are column-orthogonal matrices. When the three matrices are multiplied together the original term-by-document matrix is re-composed. Typically we can choose $k' \ll k$ obtaining the approximation $\mathbf{T} \simeq \mathbf{U}\mathbf{\Sigma_{k'}}\mathbf{V}^T$.

LSA can be viewed as a way to overcome some of the drawbacks of the standard vector space model (sparseness and high dimensionality). In fact, the LSA similarity is computed in a lower dimensional space, in which second-order relations among terms and texts are exploited. The similarity in the resulting vector space is then measured with the standard cosine similarity. Note also that LSA yields a vector space model that allows for a *homogeneous* representation (and hence comparison) of words, sentences, and texts. For representing a word set or a sentence in the LSA space we use the *pseudo-document* representation technique, as described by Berry (1992). In practice, each text segment is represented in the LSA space by summing up the normalized LSA vectors of all the constituent words, using also a *tf.idf* weighting scheme (Gliozzo and Strapparava, 2005).

3.6 Issues about incongruity models

In the last ten years computational research on humor generation was mostly focused on simple jokes or puns. The strategies employed in most of the prototypes are based on some variant of incongruity-resolution theory, and in particular on the specification for verbally expressed humor implemented by Raskin and Attardo (*Semantic Script Humor Theory* (Raskin, 1985) and *General Theory of Verbal Humor* (Attardo and Raskin, 1991)). In these models the notion of *script opposition* becomes the main semantic constraint to assure the funniness of the text. Nevertheless, it is not clear why script opposition is funny. To what extent is it used to resolve incongruity (providing a semantic connection to two incompatible meanings) or to make the incongruity funny? Another problem is the use of the term *incongruity* itself, which is not well defined in the literature.

3.7 Affective-oriented incongruity

3.7.1 Affective induction and appraisal

The two main dimensions of emotions are *physiological arousal* and *hedonic valence*. The former is the rate of autonomic activity, measurable through skin conductance, heart rate, or blood pressure. The latter corresponds to pleasure (*positive valence*) or pain (*negative valence*). Mirth can be considered as an emotion with positive valence and with a high level of arousal. According to appraisal theory (Schachter and Singer, 1962; Scherer et al., 2001), when a subject is in an emotional state characterized by a strong level of arousal, the appraisal of the current situation may induce different possible emotions. In particular, if the current perceived situation is evaluated as positive (negative), then a positive (negative) emotion with the corresponding polarity will be elicited.

We claim that the process of mirth induction can be decomposed into two independent subprocesses: induction of arousal and induction of positive valence. For the latter we term *positivity* to be the set of perceptual features that allows us to evaluate a situation or event in such a way as to generate emotions with a positive hedonic tone. Obviously mirth is not the only positive emotion, and positivity is a necessary but not sufficient condition for achieving a humorous effect. But we believe that, at this early stage of investigation, it is best to focus first on positivity, and only later on the features that allows us to distinguish mirth from other positive emotions.

We distinguish between two types of process finalized to the induction of humorous effect, one *arousal-oriented* (i.e. corresponding to arousal induction), the other one *valence-oriented* (i.e. corresponding to a positive valence induction). In the following treatment this distinction is used as a filter to re-analyze some aspect of theories on verbally expressed humor, in particular those based on *incongruity-resolution* (IR).

3.7.2 Arousal-oriented IR

In all versions of IR theory, the humorous effect is obtained through the induction in the recipient of *incongruity* and subsequent of *resolution*. We consider incongruity as a particular way to induce arousal, and resolution as a way to trigger the process of emotional appraisal and the consequent elicitation of mirth. According to the above definitions, incongruity-induction is an arousal-oriented function.

The term "incongruity" is not used in a uniform way in literature, and it is necessary to put some effort into a more precise definition. One advancement in this direction was the definition of incongruity in terms of the linguistic notion of *interpretation* (Ritchie, 1999). One problem is that this definition is constrained to the field of linguistics, but in other areas of humor studies (e.g. phychology or neuroscience) the term is used as a perceptual notion (i.e. "incongruity" is used as synonym of "incongruity perception").

In the context of formal linguistics, text meaning is provided by an *interpretation function*, which connects terms to concepts and sentences to truth values.

A text is *consistent* if there are no portions of texts from which some contradiction can be inferred, otherwise it is *inconsistent*. We call *inconsistency-incongruity* the perception of the inconsistency in a text. Another situation arises from the possible ambiguity inherent in a text. If there are two or more different possible interpretations of the same text, there is what is called *semantic* or *script overlap* (Nijholt, 2007). We call *overlap-incongruity* the perception of a semantic overlap.

It is arguable that these two types of incongruity perceptions might be indistinguishable. But people generally agree on the fact that perception of inconsistency is a source of surprise, while perception of semantic overlap is a source of confusion. Nevertheless, even if there is currently no evidence of this correlation, it can be agreed that these two linguistic triggers of incongruity are very different (one is a property of one interpretation, the other one is a relation between two interpretations). This distinction is useful for computational generation because it leads to different choices in the design of a system for textual humor generation. In particular, some strategies would require generating a text presenting an internal contradiction (e.g. the punchline in a joke). In other cases it would be more effective to build an internally consistent but ambiguous text. Finally, there would be cases in which it is convenient to express both effects in the same text.

The distinction between two types of incongruity is useful also for the definition of *incongruity-resolution*, a crucial concept of the incongruity-resolution theories of humor. In particular, the resolution of inconsistency-incongruity consists of the recover of consistency (i.e. the substitution, sometimes called *frame-shifting*, of the inconsistent interpretation with another consistent one). The resolution of overlap-incongruity is performed through the induction of a semantic relation between the pair of interpretations.

3.7.3 Valence-oriented IR

If incongruity induction is the arousal-oriented part of IR, another issue consists of the identification of the valence-oriented functions, which are the elements that provide positivity and make incongruity funny. This issue is crucial because it could provide new hints to better understand the distinction between humor understanding and appreciation. There are different ways to induce positivity, for instance affective social relationship, or playful context. But in order to create a text that can be humorous even without an external context, it is necessary to embed some semantic properties that are capable of evoking positivity, and that we call *humorous properties*. We distinguish between two types: *intrinsic* and *relational humorous properties*.

In the context of IR theory, intrinsic humorous properties provide a sense of funniness to one of the interpretations of text (i.e. the second one, arising after the resolution), employing the dimensions of disproportion, absurd, transgression, exaggeration, oddness, taboo-ness, etc. This concept corresponds to "inappropriateness" property of *Surprise-Disambiguation* (SD) specification of IR theory. Relational humorous properties connect both interpretations in order to express the disproportion or the opposition of the second one with respect to the first tone. This concept corresponds to the "comparison" property of SD (Ritchie, 1999). Script opposition (e.g. as described in (Attardo and Raskin, 1991)) is a particular type of relational humorous property. Another way in which these types of properties may evoke positivity is through aesthetic pleasure, expressed as a sort of symmetry between the interpretations. These considerations do not exhaust the investigation about humorous properties, but the distinction in intrinsic and relational subtypes can be a starting point to better understand the complexity underlying some heuristic rules employed in computational humor tools.

3.7.4 IR through familiar expression variation

Phonetic and semantic similarity are the main linguistic parameters for the realization of IR in the pun generator. Their importance in IR processing is mainly due to their capability to evoke in the recipient specific association tendencies between concepts.

A possible characterization of the IR process is:

1. A gradation of phonetic similarity values is used to induce confusion (paronymy) between the original word and the new word. If the familiarity of the expression is sufficiently high, the meaning of the familiar expression is perceived.

2. In a second moment the incongruity between the new word and the context of the familiar expression is perceived. Both phonetic similarity and semantic similarity have a role. In particular, assonance with the original word acts as a trigger for the perception of incongruity, amplified by the semantic similarity. According to the claims introduced in the section above, this is an inconsistency-incongruity, based on the contrast between the new word and the expression in which it is inserted.

3. Finally, the resolution occurs when the new meaning of the expression, propagated from the new word, is perceived.

If we represent the lexicon in a dimensional space, the lexical selection problem is reduced to the identification of regions in which words, when used for familiar expression variation, maximize pun funniness. If we use the distinction between arousal-oriented and valence-oriented functions we can first consider the regions of the lexical space that maximize incongruity. In particular, we have to consider the range of phonetic and semantic similarity for which there is the best incongruity effect.

3.8 Irony

3.8.1 Definition

Irony is a specific way of performing indirect communication or interpreting a situation. This concept is at least as complex as humor. It has been widely studied in several disciplines. In this work, we will limit ourselves to the linguistic approach. Attardo (2000) wrote an interesting survey of the literature about this topic.

Kreuz and Roberts (1993) distinguish between four main types of irony: Socratic irony, dramatic irony, situational irony (or irony of fate), and verbal irony. Socratic irony is a style of communication consisting of the pretense of ignorance of a given topic, for pedagogical purposes. Dramatic irony is a situation in which the audience knows something that the character of a play or the speaker ignores. Situational irony is a state of the world in which there is a contrast between intention or expectations and the result. Finally, verbal irony is a linguistic phenomenon in which there is incongruity between the literal and intended meanings of an utterance. We focus on this last type of irony.

More specifically, verbal irony can be defined as a rhetorical device (or figure of speech or trope) in which the contrast is performed between the literal and the figurative meaning. In most definitions, the contrast is achieved through a semantic opposition, at the sentence level (e.g. negation) or at the lexical level (e.g. antonymy). Nevertheless, the ironic incongruity can be performed in other ways, for instance through exaggeration or understatement (Sperber and Wilson, 1981). This specific example is a case of *hybridization* of figure of speech, and the term *ironic hyperbole* is employed.

The reason why only some specific types of incongruity are employed to achieve irony is connected to the intentional nature of verbal irony. Unlike situational and dramatic irony, verbal irony is intrinsically intentional. Furthermore, the intention to achieve the ironic effect, and in particular the falsity of the literal meaning and the incongruity with the figurative meaning, are made explicit to the recipient. Then semantic opposition and hyperbole are possible ways of making incongruity recognizable.

3.8.2 Pragmatics of verbal irony

The introduction of speaker intentions and other notions such as relevance, salience and appropriateness contribute to characterize verbal irony as a mainly pragmatic phenomenon. This characterization has been acquired through a sequence of stages that are briefly sketched below. In classic rhetoric, verbal irony is a figure of speech and it is based on the contrast between figurative and literal meaning.

In Grice's investigation (Grice, 1975), the mechanism is similar even if projected at the pragmatic level: figurative meaning is substituted by *figurative conversational implicature*. Irony occurs with the violation of the cooperative principle, and in particular of the maxim of quality (Grice, 1989). Sperber and Wilson investigated verbal irony in the context of their Theory of Relevance. They showed examples (e.g. understatement) in which irony is achieved without the violation of the maxim of quality (Sperber and Wilson, 1981). The violation of the cooperative principle (and of any maxim) is not sufficient to lead one to look for ironical meanings, and it is necessary when referring to a target of irony. They developed a theory of irony as an *echoic mention*: the ironic expression is not used to inform anyone of its content, but is used to refer to another expression and convey some additional evaluative meaning. Subsequent studies confirmed that a speaker or writer can flout not only the maxim of quality but the other three Gricean maxims as well (Juez, 1995).

Giora performed a further generalization with the notion of *salience* (Giora, 1998). Relevance Theory assumes different processing models for similar ironic utterances. In some cases (one-step model) there is direct access to the ironic interpretation (e.g. the figurative interpretation of a metaphor). In other cases (two-step model), there is a sequential process in which the ironic interpretation comes after the recognition of the inappropriate meaning. According to the graded salience hypothesis (Giora, 1998), the direct process is applied when salient information is consistent with contextual information. The sequential process is applied when less salient meanings are intended (e.g. the literal meaning of conventional idioms).

Attardo (2000) investigated the connection between *relevance* and *appropriateness*. An ironic utterance is contextually inappropriate (because of the violation of a maxim) but at the same time relevant.

Chapter 4

Implementation

In this chapter, the approach adopted for the he approach adopted for the generation of humorous puns is presented and the resources required for its implementation are assessed.

4.1 Morphological constraints

The first lexical constraint to be imposed to the replacement pair is of the morphological type: the replacement word has the same part of speech (POS) of the original word. Without thes condition, the expression obtained after the replacement could not have any recognizable meaning. In order to perform the POS analysis, the free available tool TreeTagger was employed [1].

TreeTagger is a tool for annotating text with part-of-speech and lemma information which has been developed within the TC project at the Institute for Computational Linguistics of the University of Stuttgart. The TreeTagger has been successfully used to tag German, English, French, Italian, Greek and old French texts and is easily adaptable to other languages if a lexicon and a manually tagged training corpus are available. In table 4.1 a sample output is shown.

[1] http://www.ims.unistuttgart.de/projekte/corplex/TreeTagger

Word	**POS**	**Lemma**
The	DT	the
TreeTagger	NP	TreeTagger
is	VBZ	be
easy	JJ	easy
to	TO	to
use	VB	use
.	SENT	.

Table 4.1: Sample output.

The tool employs a set of 36 tags, corresponding to different POS . English tagset is a refinement of Penn-Treebank tagset: The second letter of the verb part-of-speech tags is used to distinguish between forms of the verb "to be" (B), the verb "to have" (H), and all the other verbs (V). So, "VHD" is the POS tag for the past tense form of the verb "to have", i.e. for the word "had". Penn-Treebank tagset is described in (Marcus et al., 1993) and showed in Table 4.2.

In the procedure of lexical selection, the tagset was restricted to 4 tags corresponding to "noun", "adjective", "verb", and "adverb". The reason is that the lexical resources employed for the semantic selection are based on dictionaries in which words are tagged only with these POS.

4.2 Phonetic tool

The second lexical constraint, imposed to the word pair in the lexical substitution, is necessary to induce the recognition of the familiar expression. It consists of a phonetic similarity relation. If the replacement word is phonetically equal (i.e. has same phonetic transcription) to the target word, the new expression is perceived as equal to the original one. In other words, the familiar expression is recognized but there is no incongruity perception. On the other hand, if the phonetic expressions of the two words are too different, the recognition of the familiar expression is much more difficult and then can be impaired.

#	Tag	Pos Name
1	CC	Coordinating conjunction
2	CD	Cardinal number
3	DT	Determiner
4	EX	Existential
5	FW	Foreign word
6	IN	Preposition or subordinating conjunction
7	JJ	Adjective
8	JJR	Adjective, comparative
9	JJS	Adjective, superlative
10	LS	List item marker
11	MD	Modal
12	NNS	Noun, singular or mass
13	NNS	Noun, plular
14	NP	Proper noun, singular
15	NPS	Proper noun, plural
16	PDT	Predeterminer
17	POS	Possessive ending
18	PP	Personal pronoun
19	PP$	Possessive pronoun
20	RB	Adverb
21	RBR	Adverb, comparative
22	RBS	Adverb, superlative
23	RP	Particle
24	SYM	Symbol
25	TO	*to*
26	UH	Interjection
27	VB	Verb, base form
28	VBD	Verb, past tense
29	VBG	Verb, gerund or present
30	VBN	Verb, past participle
31	VBP	Verb, non-3rd person singular present
32	VBZ	Verb, 3rd person singular present
33	WDT	Wh-determiner
34	WP	Wh-pronoun
35	WP$	Possessive wh-pronoun
36	WRB	Wh-adverb

TABLE 4.2: Penn Treebank Tag Set.

Therefore, it is necessary to take in account, for the two words in the replacement, the relation of "partial phonetic similarity", called *paraphony* (or *paronymy*). Two words are paronyms when their phonemic representations are similar but not identical. Paraphony is a specific type of *heterophony* (i.e. the general relation between words with different phonetic expression). *Paronomasia* (or *punning*) is defined as the use of words similar in sound to achieve a specific effect as humor. Puns created through paronomasia are called *paronomasic*, *imperfect*, or *heterophonic puns* (Hempelmann, 2003). In general, two paronyms are then perceived as phonetically similar. More specifically, there are different possible criteria according to which the perception of phonetic similarity can occur. In the present context, paronymy is defined according to the specific task of familiar expression recognition. Two words are defined as paronyms (or phonetically similar) if the lexical substitution allows the listener to recognize, with a significant probability, the familiar expression currently employed.

A possible approach for the identification of homophones, heterophones, and paronyms consists of the measure of phonetic distance between words. A part from the trivial case of homophony (corresponding to phonetic distance 0), it is possible to identify a specific range of paraphony. In this work, phonetic similarity is treated as a dichotomous variable. Phonetic distance, defined as a real value in [0,1], can be mapped to phonetic similarity variables defined in other works as numerical variable (Crestani, 2002; Garcia et al., 1999; Manurung et al., 2008). For instance, homophones are identified here by phonetic distance 0, corresponding to numeric phonetic similarity 1. Another reason for the adoption of a numerical measure of phonetic distance is to provide ranking to quality of expression variation. For example, if two substitutions are characterized by the same values of semantic constraints, the word couple with less phonetic value is preferable because the corresponding familiar expression is more recognizable. Finally, the required definition of phonetic distance needs to be computationally tractable in order to provide an automatic measure. According to these requirements, the approach adopted was based on the notion of *Levenshtein distance*.

4.2.1 Phonetic distance

The algorithm for the measure of the phonetic distance is a specific implementation of the Levenshtein distance (Levenshtein, 1966). It is based on a sequence of elementary operations applied on the phonetic expression of a word in order to obtain another word. Each step (i.e. application of an operation) is associated to the value of a cost function. The sequence of steps, required to transform the first word in the second one, and corresponding to the minimum total value of cost, defines the distance between two words. Three types of elementary operations are considered: *substitution*, *insertion* and *deletion*.

The cost value associated to the substitution operator was assigned according to the phonetic type, tonic accent, and vowel length. The algorithm reduces the phonetic distance between words to the distance between syllables, and the syllabic distance to the distance between single phonemes, as illustrated below:

- **Distance between phonemes.** Phonemic distance gets values between 0 and 1, according on the phoneme type. For example, the distance between two vowels is lower than the distance between a vowel and a consonant; two dental consonants (e.g. ‘t’ and ‘d’) have lower distance than a dental and velar (e.g. ‘t’ and ‘k’), etc. The comparison between vowels takes in account both the accent and the length: if the vowels have both a tonic accent or are both short vowels, the distance is lower than other cases.

- **Distance between syllables.** We define syllabic distance as the Levenshtein distance between the two corresponding sequences of phonemes. For example, if two syllables have the same number of phonemes, the main contribution to the distance comes from the phonemic comparison. Instead, if two syllables have different phonemic length, then the difference in the number of syllables may weight more than the phonemic comparison.

- **Distance between words.** We define phonetic lexical distance as the Levenshtein distance between the two corresponding sequence of syllables. The decomposition of words in syllables is performed automatically. The distance is normalized to the length of the longest syllabic sequence. In particular, the zero value corresponds to the case of two perfect homophones (e.g. *weight* and *wait*).

Syllabic Length	Word Number
1	31209
2	99806
3	50318
4	14499
5	3226
6	554
7	73
8	8

TABLE 4.3: Number of phonetic dictionary words, corresponding to syllabic length.

The procedures described above allow us to create, for each word, a list of words sorted according on increasing values of phonetic distance. Given the high number of items on which calculate the distance (see Table 4.3), the process is time consuming. Therefore we need to index the phonetic distance between word pairs and the list of words sorted according on the increasing value of phonetic distance. Given a one-syllable word, the phonetic distance with each of the other words was calculated and the list was sorted according on the distance value. We consider only values until 0.2 were because, after a qualitative survey, for higher values the couples of words are perceived as too different.

4.2.2 Phonetic dictionary

The information on mapping between words and their phonetic transcription was extracted from a phonetic dictionary. We used the CMU pronouncing dictionary (available at `http://www.speech.cs.cmu.edu/cgi-bin/cmudict`). It is a machine-readable pronunciation dictionary for North American English that contains over 125,000 words and their transcriptions. Each transcription represents the phonetic analysis of a word, and it is represented in the dictionary as a mapping from each word to its pronunciation in the given phoneme set. The current phoneme set contains 39 phonemes. Vowels may carry primary or secondary stress.

4.2.3 Caracteristics of the current algorithm

This specification of Levenshtein algorithm is focused on the task of punning through lexical substitution. For this reason, it is fundamentally different from other specifications corresponding to different tasks such as speech recognition. If there is a rhyme between the original word and the replacement word (e.g. same position of tonic accent and homophony between right-side of words from the stressed syllable), this feature can be very effective for the expression recognition, even if the words have different syllabic length. On the other hand, in speech recognition of a single word the syllabic length can be more important, and then the search of the possible word corresponding to a given phonetic expression has to be performed in the set of words with the same syllabic length. In some sense, the punning task is a sort of "induction of misunderstanding", in which the recognition of the original and the varied expressions are equally probable and, thus, in the opposition recognized as incongruity.

Manurung et al. (2008) adopted an analogue approach to the implementation of phonetic constraints for punning. A specific part of their research was aimed at improving the phonetic functionalities of the JAPE punning-riddle generator (Binsted et al., 1997) and subsequently integrated in the joke generator STANDUP (Ritchie et al., 2007). More specifically, a new approach, based on the measure of phonetic similarity, followed the previous approach, based on rules. The phonetic tool developed in this work presents some key differences from the corresponding one of Manuring et al. A first group of differences concerns the choice of cost values to be assigned to each phoneme. In STANDUP, each phonetic type was tagged with a set of properties and a corresponding cost value. Thus, the cost function of a phoneme pair is calculated from the individual values of each element. In our system, instead, the cost value was assigned directly to the phonetic pair (e.g. consonant/vowel, some/different consonant group, etc.). Furthermore, values and set of phonetic properties taken in account in the two systems are different. In the present system the comparison between syllables, and words are considered separately. Thus the Levensthein algorithm was applied at two levels, first in the comparison between syllables and then using the resulting cost values for the comparison between words. An algorithm was specifically developed to perform the automatic syllabification of words. At present, no evaluation was performed to compare the performance of the two systems, due to the differences in the corresponding types of pun generation. A future work can be focused on the possible integration of the two approaches.

Another possible improvement consists of taking account, in the measure of phonetic similarity, not only of the word to be replaced but also the words of the expression context. In this way, a good phonetic similarity with contextual words can make the expression recognizable even if the similarity with the target word is not good.

4.3 WordNet-Affect and Affective-Weight

All words can potentially convey affective meaning. Each of them, even those more apparently neutral, can evoke pleasant or painful experiences. While some words have emotional meaning with respect to the individual story, for many others the affective power is part of the collective imagination (e.g. words “mum”, “ghost”, “war” etc.).

Therefore, it is interesting to identify a way to measure the affective meaning of a generic term. To this aim, we studied the use of words in textual productions, and in particular their co-occurrences with the words in which the affective meaning is explicit. As claimed by Ortony et al. (1987), we have to distinguish between words directly referring to emotional states (e.g. "fear", "cheerful") and those having only an indirect reference that depends on the context (e.g. words that indicate possible emotional causes as "monster" or emotional responses as "cry"). We call the former *direct affective words* and the latter *indirect affective words*.

The main contributions of this work consist on (i) the organization of the direct affective words and synsets inside WordNet-Affect, an affective lexical resource based on an extension of WordNet, and on (ii) a selection function (named *affective weight*) based on a semantic similarity mechanism automatically acquired in an unsupervised way from a large corpus of texts (100 millions of words), in order to identify the indirect affective lexicon.

Applied to a concept (e.g. a WordNet synset) and an emotional category, this function returns a value representing the semantic affinity with that emotion. In this way it is possible to assign a value to the concept with respect to each emotional category, and eventually select the emotion with the highest value. Applied to a set of concepts that are semantically similar, this function selects subsets characterized by some given affective constraints (e.g. referring to a particular emotional category or valence).

As we will see, we are able to focus selectively on positive, negative, ambiguous or neutral types of emotions. For example, given "difficulty" as input term, the system suggests as related emotions: identification, negative-concern, ambiguous-expectation, apathy. Moreover, given an input word (e.g. "university") and the indication of an emotional valence (e.g. positive), the system suggests a set of related words through some positive emotional category (e.g. "professor" "scholarship" "achievement") found through the emotions enthusiasm, sympathy, devotion, encouragement.

These fine-grained kinds of affective lexicon selection can open up new possibilities in many applications that exploit verbal communication of emotions.

A-Labels	*Valence*	*Examples of word senses*
JOY	positive	noun `joy#1`, adjective `elated#2`, verb `gladden#2`, adverb `gleefully#1`
LOVE	positive	noun `love#1`, adjective `loving#1`, verb `love#1`, adverb `fondly#1`
APPREHENSION	negative	noun `apprehension#1`, adjective `apprehensive#3`, adverb `anxiously#1`
SADNESS	negative	noun `sadness#1`, adjective `unhappy#1`, verb `sadden#1`, adverb `deplorably#1`
SURPRISE	ambiguous	noun `surprise#1`, adjective `surprised#1`, verb `surprise#1`
APATHY	neutral	noun `apathy#1`, adjective `apathetic#1`, adverb `apathetically#1`
NEGATIVE-FEAR	negative	noun `scare#2`, adjective `afraid#1`, verb `frighten#1`, adverb `horryfyingly#1`
POSITIVE-FEAR	positive	noun `frisson#1`
POSITIVE-EXPECTATION	positive	noun `anticipation#1`, adjective `cliff-hanging#1`, verb `anticipate#1`

TABLE 4.4: Some of emotional categories in WORDNET-AFFECT and some corresponding word senses

4.3.1 WordNet-Affect and the Emotional Categories

WORDNET-AFFECT is an extension of WORDNET database (Fellbaum, 1998), including a subset of synsets suitable to represent affective concepts. Similarly to our method for domain labels (Magnini and Cavaglià, 2000), we assigned to a number of WORDNET synsets one or more affective labels (*a-labels*). In particular, the affective concepts representing emotional state are identified by synsets marked with the a-label EMOTION. There are also other a-labels for those concepts representing moods, situations eliciting emotions, or emotional responses. WORDNET-AFFECT is freely available for research purpose at `http://wndomains.itc.it`. See (Strapparava and Valitutti, 2004) for a complete description of the resource.

	# Synsets	*# Words*	*# Senses*
Nouns	280	539	564
Adjectives	342	601	951
Verbs	142	294	430
Adverbs	154	203	270
Total	918	1637	2215

TABLE 4.5: Number of elements in the emotional hierarchy.

Recently, we extended WORDNET-AFFECT with a set of additional a-labels (i.e. the emotional categories), hierarchically organized, in order to specialize synsets with a-label EMOTION. In a second stage, we introduced some modifications, in order to distinguish synsets according to emotional valence. We defined four addictional a-labels: POSITIVE, NEGATIVE, AMBIGUOUS, NEUTRAL. The first one corresponds to "positive emotions", defined as emotional states characterized by the presence of positive edonic signals (or pleasure). It includes synsets such as `joy#1` or `enthusiasm#1`. Similarly the NEGATIVE a-label identifies "negative emotions" characterized by negative edonic signals (or pain), for example `anger#1` or `sadness#1`. Synsets representing affective states whose valence depends on semantic context (e.g. `surprise#1`) were marked with the tag AMBIGUOUS. Finally, synsets referring to mental states that are generally considered affective but are not characterized by valence, were marked with the tag NEUTRAL.

Positive	**Negative**	**Ambiguous**	**Neutral**	**Total**
97	156	20	7	*280*

TABLE 4.6: Valence distribution of emotional categories.

An other important property for affective lexicon concerning mainly adjectival interpretation is the stative/causative dimension (Goy, 2000). An emotional adjective is said *causative* if it refers to some emotion that is caused by the entity represented by the modified noun (e.g. "amusing movie"). In a similar way, an emotional adjective is said *stative* if it refers to the emotion owned or felt by the subject denoted by the modified noun (e.g. "cheerful/happy boy").

Related Emotional Term	*Positive Emotional Category*	*Emotional Weight*
university	ENTHUSIASM	0.36
professor	SYMPATHY	0.56
scholarship	DEVOTION	0.72
achievement	ENCOURAGEMENT	0.76
	Negative Emotional Category	
university	DOWNHEARTEDNESS	0.33
professor	ANTIPATHY	0.46
study	ISOLATION	0.49
scholarship	MELANCHOLY	0.53
	Ambiguous Emotional Category	
university	AMBIGUOUS-HOPE	0.25
career	EARNESTNESS	0.59
rector	REVERENCE	0.57
scholar	REVERENCE	0.67
	Neutral Emotional Category	
university	WITHDRAWAL	0.12
faculty	APATHY	0.13
admission	WITHDRAWAL	0.31
academic	DISTANCE	0.35

TABLE 4.7: Some terms related to "university" through some emotional categories

4.3.2 Affective Semantic Similarity

A crucial issue is to have a mechanism for evaluating the similarity among generic terms and affective lexical concepts. To this aim we estimated term similarity from a large scale corpus.In particular we implemented a variation of Latent Semantic Analysis (LSA) in order to obtain a vector representation for words, texts and synsets.

In LSA (Deerwester et al., 1990), term co-occurrences in the documents of the corpus are captured by means of a dimensionality reduction operated by a Singular Value Decomposition (SVD) on the term-by-document matrix. For the experiments reported in this paper, we run the SVD operation on the British National Corpus[2].

The resulting LSA vectors can be exploited to estimate both term and document similarity. Regarding document similarity, Latent Semantic Indexing

[2]The British National Corpus is a very large (over 100 million words) corpus of modern English, both spoken and written (BNC-Consortium, 2000).

(LSI) is a technique that allows us to represent a document by means of a LSA vector. In particular, we used a variation of the *pseudo-document* methodology described in (Berry, 1992). This variation takes into account also a *tf-idf* weighting schema (see (Gliozzo and Strapparava, 2005) for more details). Each document can be represented in the LSA space by summing up the normalized LSA vectors of all the terms contained in it. Also a synset in WordNet (and then an emotional category) can be represent in the LSA space, performing the pseudo-document technique on all the words contained in the synset. Thus it is possible to have a vectorial representation of each emotional category in the LSA space (i.e. the *emotional vectors*). With an appropriate metric (e.g. cosine), we can compute a similarity measure among terms and affective categories. We defined the *affective weight* as the similarity value between an emotional vector and an input term vector.

For example, the term "sex" shows high similarity with respect to the positive emotional category AMOROUSNESS, with the negative category MISOGYNY, and with the ambiguous valence tagged category AMBIGUOUS_EXPECTATION. The noun "gift" is highly related to the emotional categories: LOVE (with positive valence), COMPASSION (with negative valence), SURPRISE (with ambiguous valence), and INDIFFERENCE (with neutral valence).

4.4 Database of familiar expressions

The base for the strategy of familiar expression variation is the availability of a set of expressions that are recognized as familiar by English speakers.

We considered a specific type of familiar expressions: famous movie titles. We collected 290 titles selected from the Internet Movie Database (`www.imdb.com`). In particular, we considered the list of the best movies in all sorts of categories based on votes from users.

4.5 Algorithm

In this section, we describe the algorithm we developed to perform the creative variation of an existing familiar expression.

1. **Insertion of an input concept.** The first step of the procedure consists of the insertion of an input concept. This is represented by one or more words, a set of synonyms, or a WordNet synset. In the latter case, it is identified through a word, the part of speech (noun, adjective, verb, or adverb), and the WordNet sense number, and it corresponds to a set of synonyms. Using the pseudo-document representation technique described above, the input concept is represented as a vector in the LSA vector space. For example, a cruise vacation agency may seek to produce a catchy message on the topics "vacation" and "beach".

2. **Generation of the target-list.** A list (named *target-list*) including terms that are semantically connected (in the LSA space) with the input concept(s) is generated. This target list represents a semantic domain that includes the input concept(s). For example, given the vector representing "vacation", "beach", LSA might return the list "sea", "hotel", "bay", "excursion", etc.

3. **Association of assonant words.** For each word of the target-list one or more possible *assonant words* are associated. Then a list of word pairs (called *variation-pairs*) is created. The list of variation-pairs is filtered according to several constraints. The first is syntactic (elements of each pair must have the same part of speech). The second is semantic (i.e. the second element of each pair must not be included in the target-list), and its function is to realize a semantic opposition between the elements of a variation pair. Finally, to each variation pair an *emotion-label* (representing the emotional category most similar to the substituting word) is provided with the corresponding affective weight. Some possible assonant pairs for the example above are: *(bay, day)*, *(bay, hay)*, *(hotel, farewell)*, etc.

4. **Creative variation of familiar expressions.** In this step, the algorithm gets as input a set of familiar expressions (in particular, proverbs and movie titles) and, for each of them, generates all possible variations. The list of altered expressions is ordered according to the global affective weight.

Following our example, a resulting ad could be *Tomorrow is Another Bay* as a variation of the familiar expression *Tomorrow is Another Day*. Note that for the moment the final choice among the best resulting expressions proposed by the system is left to human selection.

At this point, the altered expression is animated with kinetic typography. In particular, words are animated according to the underlying emotion to emphasize the affective connotation.

4.6 Examples of Usage

The affective weight function can be used in order to select the emotional categories that can best express or evoke valenced emotional states with respect to input term. Moreover, it allows us to identify a set of terms that are semantically similar to the input term and that share with it the same affective constraints (e.g. emotional categories with the same value of valence).

For example, given the noun *university* as input-term, it is possible to ask the system for related terms that have a positive affective valence, possibly focussing only to some specific emotional categories (e.g. SYMPATHY). On the other hand given two terms, it is possible to check whether they are semantically related, and with respect to which emotional category. Table 4.7 shows a portion of affective lexicon related to "university" with some emotional categories grouped by valence.

In addition we also implemented a procedure for the automated generation of evaluative expressions. These expressions are composed by a part referring to the evaluated object (i.e. *target*) and a part expressing the affective evaluation on it. For example, the target can be represented by a noun and the evaluation by a *causative* adjective (see Section 4.3.1), generating an expression consisting of a noun phrase.

The procedure gets in input a generic term and a fixed value of valence and creates the corresponding LSA-vector. Then, the system selects the emotional category with the input valence and the maximum value of affective weight. Finally, depending on the type of required expression, target-term and and evaluative-term are selected and the corresponding expression is composed. For example, if we give in input the verb "shoot" with negative valence, the system identifies the emotional category HORROR. Then, it extracts the noun "gun" (similar to "shoot") and the causative evaluative adjective "frightening" and finally generates noun phrase "frightening gun".

Starting from an input concept (e.g. *disease*) we can obtain, using semantic similarity, a list of related terms (Table 4.8).

Name	POS	Similarity to the input
symptom	noun	0.971
therapy	noun	0.969
metabolism	noun	0.933
analgesic	noun	0.899
suture	noun	0.851
thoracic	adjective	0.782
extraction	noun	0.623

TABLE 4.8: Input word: "disease"

Using the affective weight function, it is possible to check for their affective characterization (in Table 4.9 only four emotions are displayed), selecting only those affectively coherent with the input term. Subsequently, the system searches for assonant words (Table 4.10) checks for affective opposition with the original words (Table 4.11).

At this point, the system retrieves familiar expressions that include the word to be substituted.

Name	fear	joy	anger	sadness
disease	0.357	0.201	0.135	0.679
symptom	0.423	0.293	0.164	0.685
therapy	0.374	0.315	0.170	0.691
metabolism	0.372	0.258	0.082	0.552
analgesic	0.280	0.241	0.173	0.526
suture	0.237	0.299	0.227	0.490
thoracic	0.157	0.135	0.134	0.448
extraction	0.126	0.245	0.177	0.366

TABLE 4.9: Affective weight

Name	Assonant Words
suture	*future*
thoracic	Jurassic
extraction	abstraction, attraction, contraction, diffraction, distraction, inaction, reaction, retraction, subtraction, transaction

TABLE 4.10: Phonetic associations

Name	fear	joy	anger	sadness
suture	0.237	0.299	0.227	**0.490**
future	0.467	**0.571**	0.417	0.462

TABLE 4.11: Affective difference

Input Words	Varied Expression	Word Substitution
vacation, beach	Tomorrow is another bay	day → bay
disease	Back to the Suture	future → suture
	Thoracic Park	jurassic → thoracic
	Fatal Extraction	attraction → extraction
crash	Saturday Fright Fever	night → fright
fashion	Jurassic Dark	park → dark

TABLE 4.12: More Examples

Table 4.12 shows the final word substitution in several examples. The system can then automatically animate the resulting expression emphasizing the novel affective connotation through kynetic typography techniques as shown in (Strapparava et al., 2007).

Chapter 5

Use of the system for empirical investigation

5.1 Introduction

The system can be used as testbed for the study of the process of humor understanding. In the hypothesis of humor as a way to elicit mirth, the system can be considered a generator of linguistic stimuli with a given set of properties, and inducing a corresponding emotional response. The main implication is the possibility to adopt well-known methodologies from experimental psychology for the measure of affect.

One way consists of the study with human judges based on the analysis of their introspective reports. People are generally able to distinguish a funny statement from a not funny one. In some cases, not funny does not correspond to a neutral response. For example, some people can experience witty remarks, containing obscene terms or evoking racist opinions, as embarrassing or offensive. In these case, it is important to detect which are other possible emotions induced by expressions of the same type, in order to identify the elements that make the difference in the achieving of the humorous effect. Other ways to recognize the humorous effect (i.e.

mirth) can be based on the measure of physiological (e.g. heart-rate or skin conductance) or behavioral features.

Finally, neurophysiology and brain-imaging techniques allows us to detect the functional activity of the nervous system during the process of humor understanding and appreciation. With these approaches it is possible, on one hand, to measure the main dimensions of the emotional response (i.e. arousal and valence), but, on the other hand, also some of the cognitive variables that are part of the appraisal process. More specifically, the testbed can be used to study the relation between the perception of incongruity (considered as an appraisal dimension) and the variations of autonomic arousal.

5.2 Preliminary study with subjects

In a study preliminary to the adoption of the pun generator described earlier, we have just considered taboo words (without having to consider the real process of generation based on semantic distance techniques, and therefore limiting the fuzziness of this component, and phonetic distance. *Taboo-ness* (i.e., the property of being a taboo word such as an obscene or sexual term) is one of the best known elementary linguistic forms for attracting attention and provoking surprise. Under appropriate circumstances that we considered essentially correlated to the phonetic distance between word to substitute and novel word a substitution with a tabbo word can provoke a humorous effect. Taboo-ness was the characterising attribute of a collection of sex words collected from the WordNet lexical database and Latent Semantic Analysis over the British National Corpus. The data analysis shows that, in puns recognized by subjects as funny, humor appreciation is correlated both with phonetic distance and taboo-ness.

5.2.1 Methodology

5.2.1.1 Choice of variables

We consider four variables: *phonetic distance* (described in the previous chapter) and *taboo-ness* as independent variables, and *humorous rank* and *agreement* as dependent variables.

- **Taboo-ness.** The semantic constraint consists of the choice of taboo words (e.g. sex words, curses, or insults). We suppose that, for some type of recipient and in some given context, the use of these words makes the text funny, because it has an active role in the realization of the effect described in relief/release theories of humor (Freud, 1905). The advantage in the use of taboo words is that there is no need for contextual information: we suppose that a simple form of humor it is possible in this case.

- **Humorous rank.** Given a set of textual items, we define the *humorous rank* to be the ratio between the number of items judged as funny and the total number of items. In this study, items are puns and sets are clusters of puns organized according to phonetic distance and taboo-ness.

- **Agreement.** Even when two subjects have the same value for humorous rank, this does not imply that they perceive as funny the same set of items. In this case it is useful to consider items with a fixed value of inter-subject positive agreement for funniness. We define the *agreement set* to be the cluster of puns tagged as funny by the same number of subjects, and *agreement value* as this number.

Now our hypothesis can be reformulated in terms of the above defined variables, and consists of the inverse correlation of humorous rank and the positive agreement with phonetic distance and direct correlation with taboo-ness.

5.2.1.2 Materials

We selected 600 variations (through lexical substitution) of movie titles generated by the testbed. Only word substitutions with the same part of speech and syllabic length were taken into account, in order to preserve well-formedness and help the recognizability of the original title. In half of items (300) the title was varied in order to include a taboo word. The subset containing taboo words was further split into 5 clusters, each corresponding to a different range of phonetic distance between the original word and the new word. Phonetic intervals had a length of 0.15, with a range from 0.00 to 0.75. We do not consider higher values for the phonetic distance because, during a preliminary survey, we concluded that for these values, the new word is perceived as too different to induce the recognition of the original word. An analogous split into 5 subsets was performed for the list of items not including taboo words.

To sum up we selected 10 clusters of 60 elements. The elements of each cluster were randomly selected. Finally all clusters were randomly mixed to avoid a cluster recognition effect. For example if the subject identifies a series of items as elements of the cluster with low phonetic distance and taboo words, (s)he might propagate the same information to the remaining elements, without really focusing on their content.

5.2.1.3 Choice of subjects

We considered a sample of 40 subjects. They were all students and researchers at Twente University in the Netherlands, with a good knowledge of English, and only some being English native speakers. Before providing the questionnaire with the expression list, we had a brief conversation with each participant in order to explain the modalities of the annotation, to be sufficiently sure that reading the expressions with taboo words would not be embarrassing or offensive. All the required subjects did not express any perplexity at partecipating in the experiment, even though in two cases we found post-experiment comments on the form warning about the potential offensive content of some items.

5.2.2 Description of the experiment

The list of expressions was provided to each subject. The task consisted of a reading and a tagging of each expression, according to one of four possible outcomes of the reading:

1. *I find it funny now.*
2. *It might be funny but not for me or not now.*
3. *I cannot judge (e.g. I cannot recognize the original title, or understand some word).*
4. *It is not funny at all.*

In particular, the distinction between *1* and *2* is based on the following two hypotheses:

i The humorous effect of these puns is only partially due to their linguistic content. It also depends on the context in which the expression is uttered. A good pun, to be really capable to make people laugh, has to be communicated to the appropriate recipient and in the appropriate moment.

ii Adult people are able to judge if a pun might be "good" even if they are not experiencing mirth in that specific moment. This claim is based on the distinction between *humor understanding* and *humor appreciation* (Suls, 1972; Bartolo et al., 2006). People may understand a joke without appreciating it. We suppose that human beings also have the ability to distinguish if the joke they are not appreciating is "a good joke", even it might be appreciated in other contexts. Additional possible support for this hypothesis is the fact that none of the subjects reported any uncertainty about the tagging of expressions according to this distinction.

With these claims we can consider a higher number of potentially funny puns, even if the experimental conditions are not suitable to put the subject in the best mental state for the humor appreciation. Furthermore, we considered that humor based on explicit taboo words is in some way childish and, for some people, embarrassing or offensive. Nevertheless people can admit that some jokes can be funny for others.

5.2.3 Results

5.2.3.1 Humorous rank

In Table 5.1, the values of humorous rank according to taboo-ness and ranges of phonetic distance are shown. In the calculation of humorous rank, three different types of puns (and corresponding clusters containing them) were taken into account: puns with taboo words (**Taboo**), puns without taboo words (**Non-Taboo**), and puns with or without taboo words (**All**). As shown, the highest value for humorous rank corresponds to the taboo cluster with the lowest range of phonetic distance.

P-Range	Taboo	No-Taboo	All
0.00 – 0.15	0.210	0.063	0.137
0.15 – 0.30	0.101	0.032	0.066
0.30 – 0.45	0.065	0.029	0.047
0.45 – 0.60	0.061	0.032	0.047
0.60 – 0.75	0.047	0.020	0.034

Table 5.1: Values of humorous rank according on different pun clusters.

In Figure 5.1, the variation of humorous rank according to taboo-ness and different phonetic ranges is represented. It is possible to observe that in all graphs humorous rank increases at with smaller values for phonetic

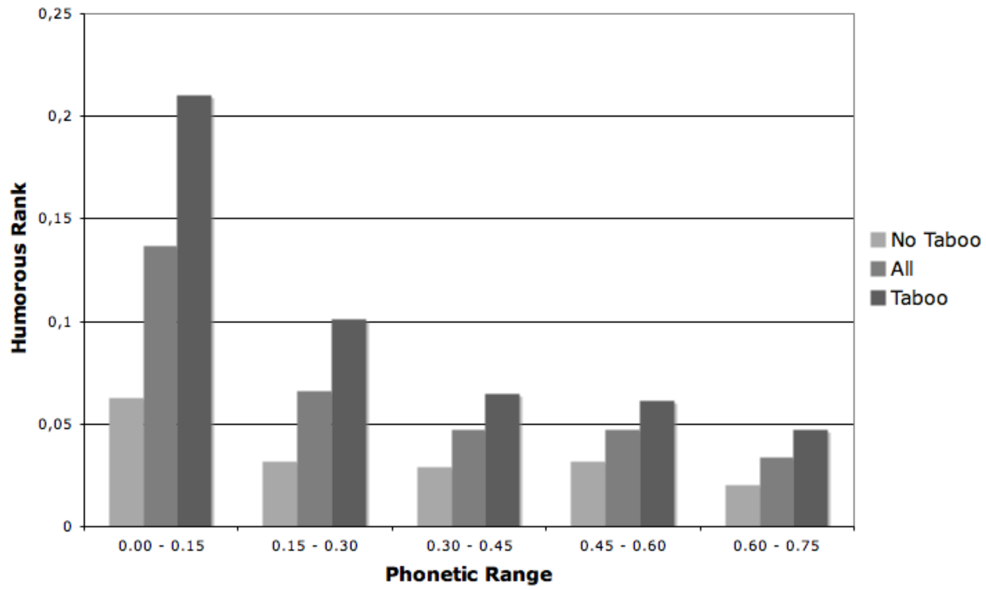

FIGURE 5.1: Graphs of humorous rank corresponding to different datasets.

Pun	Agreement	Substitution	P-Similarity	Taboo-ness
Woman: Impossible	22	mission/woman	0.22	no
The Lost World : Jurassic Porn	19	park/porn	0.12	yes
Passion: Impossible	19	mission/passion	0.13	yes
Lust Busters	16	ghost/lust	0.13	yes
The Sexed Sense	16	sixth/sexed	0.13	yes
Finding Homo	16	nemo/homo	0.13	yes
Ass Age	15	ice/ass	0.04	yes
Lara Croft: Tomb Rubber	14	raider/rubber	0.12	yes
Kissing: Impossible	14	mission/kissing	0.26	yes
Forrest Dump	12	gump/dump	0.10	yes
How to Light a Guy in 10 Days	12	lose/light	0.30	no
Notting Feel	10	hill/feel	0.15	yes

TABLE 5.2: Puns sorted according on positive agreement.

distance. To quantify the correlation of humorous rank with phonetic range and taboo-ness, we employed Pearson's coefficient r_P (one-tailed, $p < .02$). The resulting value is $r_{P-all} = -0.51$, representing a "good" correlation. In the case of taboo clusters, the correlation is slightly higher ($r_{P-taboo} = -0.52$). Instead, in the case of the non-taboo cluster, the correlation is not sufficiently proven ($r_{P-no-taboo} = -0.29$). This implies that phonetic similarity, without taboo-ness, is not sufficient to realize the humorous effect.

To measure the correlation of humorous rank with taboo-ness, we used the point-biserial coefficient r_{PB} (one-tailed, $p < .01$). The resulting value is $r_{PB} = 0.54$. This confirms the role of this semantic constraint for the humor appreciation.

5.2.3.2 Agreement

In Table 5.2 some items of the list of puns sorted according on decreasing values of agreement are shown. We used Pearson's coefficient to measure both agreement correlation with phonetic distance and with taboo-ness (in this case measured as the frequency of taboo puns). The values are respectively $r^{phon}_{P-agree} = -0.78$ and $r^{phon}_{P-agree} = 0.73$ (one-tailed, $p < .02$) and confirm the correlation.

The value of humorous rank is low for any applicative use. Current constraints are not sufficient to provide an expression with a good probability of being humorous. Nevertheless our aim is to provide a measurable parameter and a baseline with which to assess the improvement of pun generators. Even if the humorous rank is relatively low, it is interesting that the preferences are concentrated in a small number of sentences. More interestingly, most of preferences are for expressions with the constraints meant to be humorous (i.e. phonetic similarity and presence of taboo words).

5.2.4 Discussion

5.2.4.1 Humorous rank and control of humorous acts

Humorous acts are risky and difficult to control. In order to increase control to a satisfying level, it is necessary to measure the probability of fulfilling the humorous effect. Humorous rank is a simple way to measure this probability and provide a baseline for the evaluation of other computational humor systems.

Satisfactoriness of humor probability depends on the applicative context being taken into account. For example, if a humorous expression is used to realize banners for advertising a web site, a relatively low value of humorous rank might be sufficient to increase the number of contacts on that link. But if the humorous expression is an advertising headline with a more complex persuasive goal (buying a specific product), a solid humorous ranking might be insufficient to provide the required effectiveness.

In some contexts it is necessary to consider the potential effect of expressions even if they are not humorous, for ethical reasons. The issue is particularly important in the case of taboo humor, because it could turn out to be particularly offensive, and this eventuality in most cases has to be avoided. In the case of our system, it is necessary to determine the potential reader/hearer of the taboo pun.

Furthermore, a better understanding of the effect of lexical substitution at the sentence level is necessary. Finally, the textual content of humorous expressions is only one of the important elements that contribute to humor probability, the other being appropriateness. In other words, to become a humorous act the text has to be communicated in the appropriate way. This is particularly true for puns and humor in conversations and other interactive contexts.

5.2.4.2 Correlation and independent dimensions

Phonetic distance and taboo-ness are independent variables, implemented with different resources. The correlation with humorous rank suggests improving knowledge about the effect of both parameters on the funniness of puns. On one hand, an improvement in the phonetic tool would allow for the recognition of a larger number of phonetically similar words and corresponding variations of the original expression. On the other hand, we can explore different semantic constraints in order to implement humorous strategies not limited to taboo-ness (for example connected to the evocation of stereotypical ridiculous traits of people).

5.2.4.3 Lexical and expression meaning

The experiment allows us to observe an interesting issue, summarized in the following points:

i The lexical parameters, implemented in our systems, characterize the full set of possible variations of a given list of familiar expressions.

ii As defined above, humorous rank is measured as percentage of puns recognized as funny by human judges from a set of randomly generated outputs. Thus, it also is a collective property.

iii Nevertheless, the high agreement on a few expressions suggests that the probabilistic character of the pun set (with fixed lexical value range) is due not only to differences in the reader but also in some additional characteristic exhibited by some instance in the set.

The interesting fact is that, after the experiment, most subjects observed that the choice of funny expressions was mainly due to the overall meaning evoked by the expression. The lexicon triggers a change of meaning at the expression level. In other words, a possible explanation of the funniness of only a few specific instances in the generated pun set is that in these expressions there is a deeper semantic matching between the lexical and the expression meaning. Thus, a possible future study can be aimed at investigating the relationship between lexical and expression level.

Chapter 6

Exploratory Applications

6.1 Introduction

In this chapter we describe two exploratory applications that are connected in different ways to the pun generator described in section 3.1.

The first is a hierarchical planner for the assistance of users in the execution of complex tasks, such as learning or academic writing. This approach is aimed at addressing the user difficulties in the execution of difficult tasks, in order to reduce the frustration related to those tasks. The prototype was developed as a first component of a future system in which task-oriented assistance and humorous feedback can be integrated to achieve frustration reduction (Valitutti, 2009).

The second application is a tool for the collaborative creation of puns. It was developed for investigating the interactive creation of verbal expressions, through the integration between automatic functionalities and human creativity. In this system, the pun generator is enriched with a graphical user interface consisting of a dynamic graph, through which the textual elements (i.e. words and expressions) are showed in such a way as to convey attention and enhance user's creativity, thus improving the lexical selection employed in the humorous variation of familiar expressions (Valitutti et al., 2009).

6.2 Action decomposition and frustration regulation

In every complex or new activity there may be moments of impasse in which our repertory of skills and tools turn out inadequate. Generally, when this happens, people reorganize themselves through the development of new strategies or tools, making themselves stronger or more prepared to face the problem. This holds particularly true for learning activities (Zeidner, 1995). For example, the preparation of a university exam requires the coordination of different tasks of study, writing, and exercising tasks, and difficult occasions may be numerous. Nevertheless, the difficulty of the task induces stress and negative emotions such as frustration, and this affective state can itself be a source of feedback that increases difficulty. In other words, frustration may be a way to perceive the objective difficulty of tasks. If sufficiently intense or drawn-out, it may have an effect on attention and motivation thus reducing the overall capability to perform the task.

In the present thesis we will discuss a specific method of addressing this issue. In particular, the connection between affective recognition and action decomposition will be proposed as a way to reduce frustration occurring in the execution of difficult tasks.

Even if the relationship between difficulty and emotional state is more complex and not limited to frustration, in this work we want to emphasize the distinction and correlation between objective and subjective aspects of difficulty. Furthermore, we focus on frunstration in order to point out advancements of previous studies on frustration and human-computer interaction, such as (Klein et al., 2002) and (Hone, 2006).

6.2.1 Tasks and executor systems

In order to provide the conceptual background on which the main ideas of this study are based, some preliminary definitions will be introduced:

i Task execution requires the existence of an *executor system* capable to execute (at least) a set of *primitive actions*. This term is employed in order to consider both human and machine executors of algorithms. This choice is a way to take advantage of theoretical results and ideas from computer science and artificial intelligence, in particular planning. The analogy between humans and machines as executor of algorithms allows us to focus on the characteristics of human executors that make them different from machines. Human beings need to have not only knowledge and skills, but also motivation. In particular, emotional states strongly affect the capability and performance of task execution.

ii A task is *simple*, if it is represented by a primitive action and can be directly executed by the system, or *complex*, if it is completed through the execution of a total ordered plan (i.e., a deterministic sequence of primitive actions).

iii Given a repertory of primitive actions, there are many ways to execute a particular task. It can be represented as a set of total ordered plans or, equivalently, a partially ordered plan.

iv A set of tasks can be organized in an *action hierarchy*, in which each action is connected to the set of sub actions that allows for its execution. Therefore, a task can be represented as a structure of actions with a set of ordering constraints, in order to identify the partially ordered plan. This representation has been employed, among others, in *hierarchical decomposition partial order planners* (HD-POP) (Russell and Norvig, 1995), *hierarchical task network planners* (HTN) (Erol et al., 1996), and *partial order hierarchical reinforcement learning systems* (Hengst, 2008).

v The decomposition structure of a given task in terms of primitive actions is a hierarchical tree in which the root node corresponds to the task action and the leaf nodes correspond to the primitive actions.

vi Then the difficulty of a task, for a given executor system characterized by a set of primitive actions, can be defined as the "distance" between them and the main action, measured as the sum of lengths of all paths from the root to the leaves. The greater the distance, the more complex the plan is to perform the task. Access to strategic knowledge is crucial for the executive skill. It may have a motivational effect as well. In fact, without a plan whose steps are perceived as executable, people may believe they are not able to perform the task and the activity does not even start.

Some executor systems may have different sets of primitive actions. In the case of machines, the primitive action set depends on the structural level taken into account for the communication of instructions. For example, the interaction with a computer can proceed at the level of the machine code, the operating system, or application software. Nevertheless, even if a specific instructional context is fixed, the action set can change over time. For instance, from the point of view of the user, a programmable computer can acquire the capability of executing new tasks through the installation of new software. It is interesting to observe that, for a system that can change the primitive actions, there are two degrees of freedom in the representation of a given task, corresponding respectively to the set of primitive actions and the set of total ordered plans for a fixed action set.

In the case of human executors, the ability to execute primitive actions can be defined as the attitude to perform a task automatically, without the need to pay attention to an explicit plan. Unlike machines, the set of primitive actions is extremely variable and correlated to several factors among which are individual skills, learning, and mental state. The analysis of the next sections focuses on the dependence of primitive actions on the affective state of the human executor.

6.2.2 Assistance for task execution

A computational tool can be employed to assist the user in the execution of a complex task. This assistance may consist of the specification of a plan and its presentation to the user. The assistant checks the execution and takes initiative in the case of failure, performing a diagnostic analysis and proposing possible alternative strategies. In particular, assistance planning is a distinctive type of interactive planning, in which the planner supports a human being while trying to achieve some complex goal. An intelligent assistant capable of assistance planning decreases the work overload, which is characteristic of several activities. Furthermore, it is of great help to humans working towards the solution of certain complex problems (Lindner, 1994). An interactive assistance planner generally has a representation of the task as a partially ordered plan. This feature allows the user to choose among different paths of execution. In addition, it is a hierarchical planner: in this way, action decomposition enables the system to change the repertory of actions used in the plan in order to consider only actions that are executable by the user. The central hypothesis here is that the primitive action set can change according to a user's affective state.

We can conceive of a prototypical tool in which the assistance to the task-oriented activity is characterized by adaptability to the user's affective state, through correlation with the primitive action set. The system would consist of an Interactive Learning Environment (ILE), in order to provide a task domain, and of an assistant to the user's decision-making (Amant, 1997). If the system is able to recognize the affective state of the user (in particular, the rate of frustration), it should be able to correlate it with the current set of primitive actions. When a communicated action is not executable, the system decomposes it considering the corresponding node in the action hierarchy and extracting the actions of its subnodes. The action decomposition can be repeated until it produces a set of actions that the user can execute. The advantage of affective recognition is that, when a change of affective state occurs, the set of primitive actions is automatically updated. This model may evolve differently for each affective state: if a change of his/her mental state is recognized, it may have a corresponding change in the primitive action set and consequently in the way in which the task is communicated by the assistant (through the currently executable actions).

If in particular we consider a specific emotion such as frustration, more directly connected to the executive difficulty, the system has to be designed in order to regulate the emotional intensity through action decomposition. When task difficulty is too high for the user, frustration is generated or increased. In turn, frustration affects the cognitive state thus reducing the number of executable actions, further increasing stress until impasse occurs. Even if a possible solution could consist of a direct action on the emotional state (e.g. employing humorous or emphatic communication), the planning adaptation itself may perform a regulation of frustration. In fact, after action decomposition, plan execution becomes easier and then frustration decreases. In the opposite case (i.e. actions communicated to the user are perceived as too easy), the execution might be boring or annoying, and there is the risk of making the user less motivated to continue the interaction. In this case, some simple actions will be substituted with other more complex actions, moving up in the hierarchy.

6.2.3 Frustration regulation and affective loop

Research on affective intelligent learning environments (ILE), i.e. ILEs that include affective elements in their interaction with the student, has become increasingly prominent in the past few years, due to two main reasons. Firstly, there is growing evidence of correlations between affect and learning, fostering the belief that recognizing and responding to student affect can improve the effectiveness of pedagogical interactions. Secondly, advances in affect recognition now make it feasible to devise interactive tools that can be aware of a user's affective state, and respond accordingly.

One specific focus is on how to close what it is called the affective loop, i.e. that ensemble of four phases that together allow for the principled addition of affective elements to an ILE: (*i*) design the environment so that it can elicit affective states favorable to learning, (*ii*) recognition/modeling of relevant user's states, (*iii*) selection of appropriate system responses, and (*iv*) synthesis of the appropriate affective expressions (Conati et al., 2005).

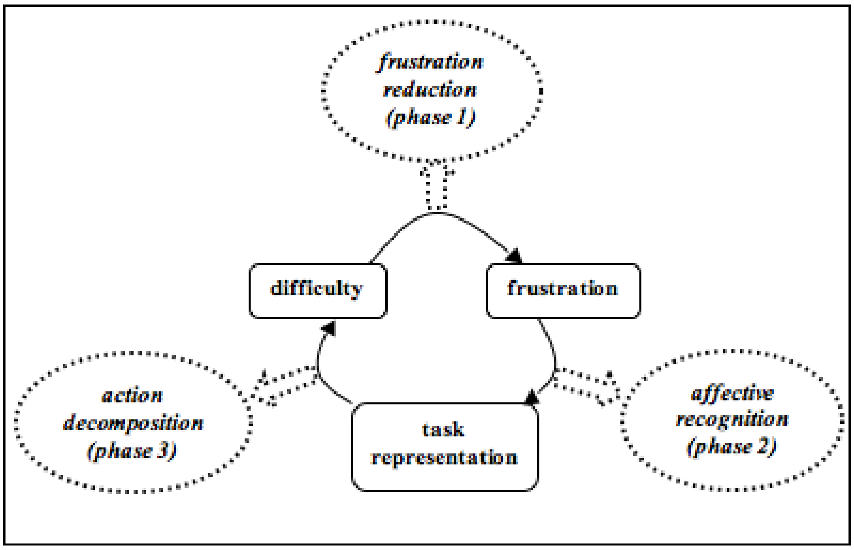

FIGURE 6.1: Frustration regulation and connection with three phases of affective loop.

If we suppose to employ assisted task execution as a particular functionality of an ILE, frustration regulation through action decomposition can be considered to be a specific type of affective loop.

Figure 6.1 shows the case of frustration reduction, the interacting key elements (i.e., *difficulty*, *frustration*, and *task representation*) and the steps of the adaptive planning corresponding to three of the affective loop phases. The steps are described below:

i **Frustration recognition.** This stage corresponds to the *emotional recognition* phase of the affective loop, performed with the state-of-the-art sensors.

ii **Action decomposition.** In this phase (corresponding to the *response* phase of the affective loop) two possible operations are performed. In the first interaction with the user, response consists of the modeling of the primitive actions and the association with the affective state. Action modeling can be performed through the analysis of impasses in the execution. In the next interactive sessions, the response would consist of the previously modeled set of actions.

iii **Difficulty reduction.** This step corresponds to the *emotional elicitation* phase of the affective loop. In fact, the presentation of an easier plan to the user reduces the sense of difficulty and we would expect frustration to decrease.

6.2.4 Conclusions

In this section the potential advantages of affective adaptivity in assisted task execution were proposed. In particular, the focus is on a very simple but general structure (an action hierarchy) and mechanism (action decomposition) and the correlation between the set of the immediately executable actions (primitive action set) and the affective state (frustration). The definition of difficulty in terms of depth of the action hierarchy for a given task allows us to distinguish beween and correlate the objective aspect of task difficulty and its subjective and affective counterparts. Finally, this framework allows us to analyze the mutual interaction between task representation and frustration, and to consider it as specific type of affective loop.

These ideas are not constrained to the domain of task execution, and might be applied also to text understanding. In this context, we can consider a concept hierarchy, a set of primitive concepts and a mechanism of concept decomposition that can be adapted to the emotional state of the student. One possible application might be the generation of text in which the terminology is adapted not only to the user knowledge (in particular, the set of primitive concepts) but also to the affective state. If the user is frustrated because the text is difficult to understand, the presentation of content can be modified in order to facilitate reading and understanding.

Finally, assistance for task execution and text understanding could be integrated into a new generation of ILEs in which frustration recognition and regulation contribute to improve learning.

6.3 Interactive creative pun generation

While the automatic generation of funny texts delivers incrementally better results, for the time being semiautomatic generation can already provide something useful. In particular, we present an interactive system for producing humorous puns obtained through variation (i.e., word substitution) performed on familiar expressions. The replacement word is selected according to phonetic similarity and semantic constraints expressing semantic opposition or evoking ridiculous traits of people. Examples of these puns are *Chaste makes waste* (variation on proverb) and *Genital Hospital* (variation on soap opera title). Lexical substitution is the humorous core on which the funniness of puns is based. We implemented an interactive tool (called GraphLaugh) that can automatically generate different types of lexical associations and visualize them through a dynamic graph. Through the interaction with the network nodes and arcs, the user can control the selection of words, semantic associations and familiar expressions. In this way, a restricted set of familiar expressions are left after filtering, the best word substitutions to apply them are easily identified, and finally a list of funny puns is created.

6.3.1 Dynamic graph

We employed TouchGraph (Alani, 2003), an open source Java environment, for designing a dynamic graph that stimulates users to explore a network of concepts and expressions. During the interaction, only the currently selected node and a number of adjacent nodes are visualized. In this way the user is free to explore creative local associations without paying attention to the overall structure.

6.3.2 Description of a session

With GraphLaugh, the process of pun generation is experienced as a creative exploration in a dynamic network of terms and expressions. Relations between pairs of nodes are not labeled and every time the user clicks on some node, it is repainted at the center of the screen and its side nodes are drawn around it and connected to it via arcs. The session is carried out across three phases, corresponding respectively to the selection of words, of semantic associations and related familiar expressions. Each phase is composed of interactive turns between user and system.

6.3.2.1 Selection of words

The user searches for one or more candidate words (e.g. `body`) to be the replacement in some familiar expression. A replacement word can be chosen according to various criteria. For example, it might be a taboo word (i.e. sexual or obscene term), used for provoking embarrassment and performing release/relief humor (Freud, 1905). Or it might be a scorning word (e.g. a negative evaluative adjective or a negatively connoted word), employed for evoking some despicable trait of people and laughing at them. Besides these simpler forms of humor it may rely on irony, and other substitutions that involve some semantic evaluation of both the target and the substituting words. Through the interface the user can initially insert an input word, and then move around the network of terms. Words are connected according to different semantic relations, for example LSA similarity (shown in Figure 6.2), one or more WordNet relations (e.g. hyperonymy or part-of), or a relation connecting words of the same topic.

6.3.2.2 Selection of semantic associations

After having selected words to consider as a replacement, the user might introduce a stronger semantic constraint. More specifically, the new word to replace might be chosen not only for its semantic properties, but also for the semantic relation with the original word in the familiar expression. For each replacement word a new graph (shown in Figure 6.3) is constructed, with the associated words as side nodes. In GraphLaugh the relations available to the user were taken in account for their capability to induce

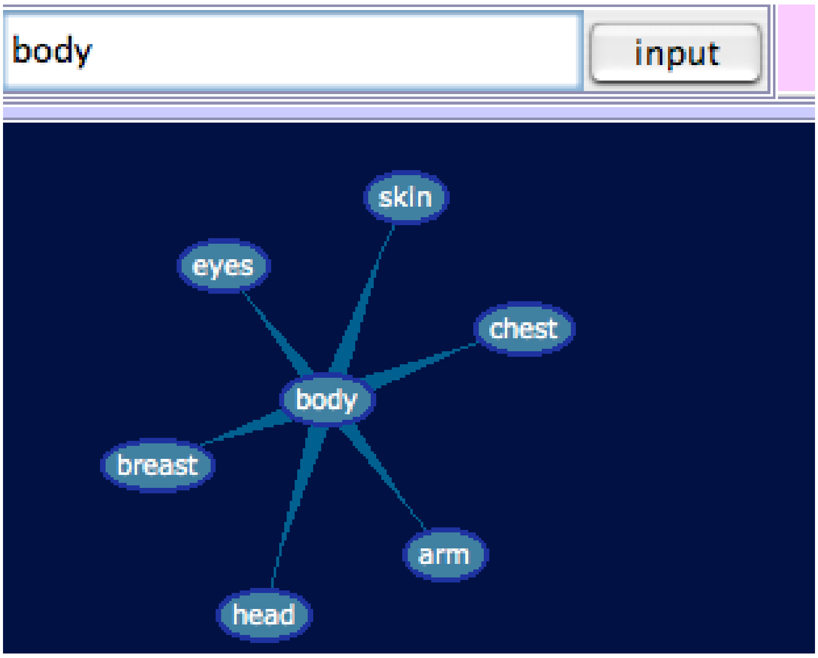

FIGURE 6.2: Choice of the replacement word.

different types of incongruity (e.g., antonymy, domain opposition, affective valence opposition). Only words that are present in at least one familiar expression are proposed.

6.3.2.3 Selection of familiar expressions

The list of relevant familiar expressions is visible and, with a click, previously selected replacement words (with the possible additional constraints mentioned above) are inserted in familiar expressions: the central node contains the word to be replaced, and the side nodes show all possible variations of familiar expressions obtained through this substitution, Substitutions are kept in a list and the best pun can be finally selected,, as shown in Figure 6.4 (a variation from the movie title “West Side Story”).

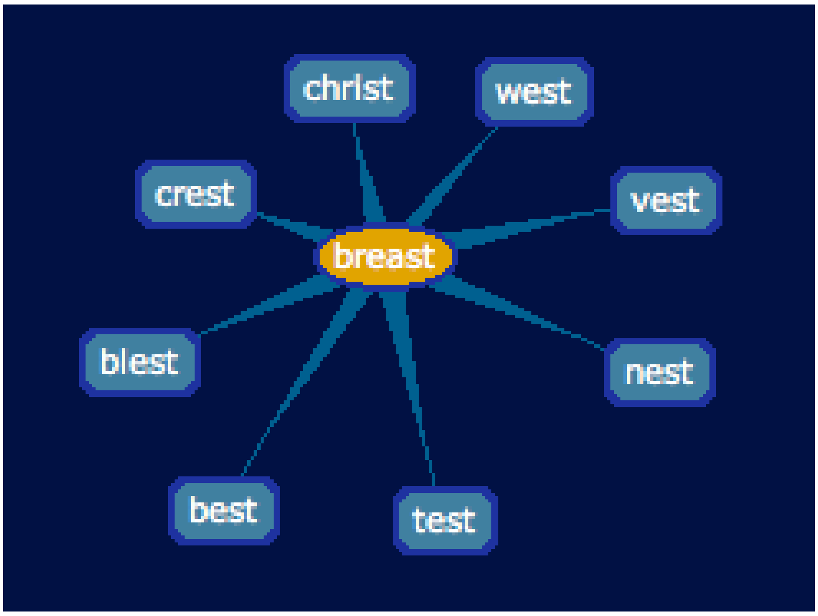

FIGURE 6.3: Choice of the word to be replaced.

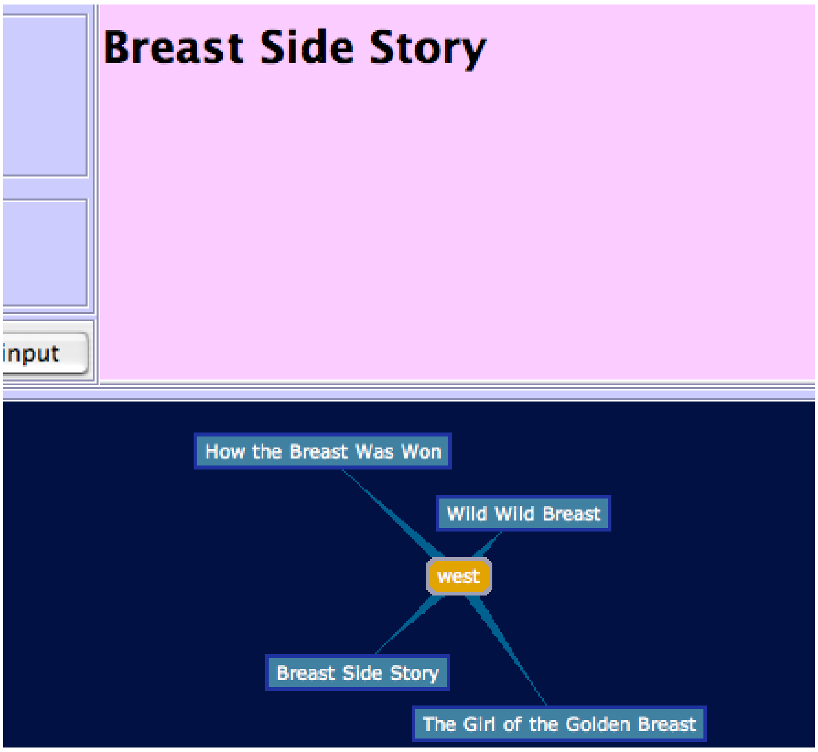

FIGURE 6.4: Selection of the preferred pun.

Chapter 7

Conclusion and future work

7.1 Conclusion

Humor is a multi-disciplinary field of research. In particular computational humor is a research area lying at the intersection between computational linguistics and artificial intelligence. It mainly aims at the implementation of tools able to generate and recognize humor automatically, but also can contribute to the study of humor through computational simulations.

In this work we provided a contribution in the specific context of verbal humor generation, focused on computational creation of humorous texts. The goal consisted of the design and implementation of a tool for the automatic generation of short humorous expressions. We focused on humorous puns generated through the variation of familiar expressions. The variation is performed via lexical substitution of one word in the original expression, reducing the problem of pun generation to a problem of lexical selection. Phonetic and semantic features are employed to select the appropriate substitution. We have chosen a corpus-based approach, in line with a tendency prevailing in the computational linguistics field. We employed a number of textual corpora and dictionaries (i.e. the British National Corpus, WordNet, WordNet-Affect, Affective-Weight, and the CMU phonetic dictionary. We have developed some of these resources

(WordNet-Affect and Affective-Weight) in an early stage of the research.

One of the key aspects in our tool is the use of functions for the measure of phonetic and semantic lexical distance. Phonetic distance is implemented according to the Levenshteins definition. We developed an enriched version of the standard procedure. For the implementation of semantic distance (defined as semantic similarity), we adopted an approach focused on the statistical processing of large-scale textual corpora. The technique, called Latent Semantic Analysis (LSA), is based on the idea that association tendency in common sense knowledge is reflected in the linguistic use in terms of co-occurrence frequency. In other words, if two concepts are naturally associated in the mind of a community of speakers, the corresponding words occur, with high frequency, in the same texts.

The distance tool is employed in the procedure of humorous expression variation at two different levels. On one hand, measure of distance allows the system to explore the semantic domain of a the word given in input. In this way, the variation of a familiar expression can refer to the desired semantic domain, in order to generate an ironic utterance about some target topic. On the other hand, the measure of semantic distance can be used to extract affective information. Sensing of affective connotation of words in the system is taken care of by a function (Affective-Weight) which allows to extract, to some extent, the polarity and the intensity of the affective meaning evoked by the word. It is employed to perform ironic effects: polarity can be used to achieve semantic opposition, and intensity can be used to achieve some forms of exaggeration.

The system can be used as a testbed for the empirical investigation of various aspects of verbal humor. More specifically, it can be used to study the correlation between linguistic parameters of humorous expressions and appraisal dimensions that are part of the cognitive process of humor understanding.

In the last phase of the work, we developed two exploratory applications: a prototype was developed as a first component of a system in which task-oriented assistance and humorous feedback can be integrated to achieve frustration reduction. The other application developed is a tool for the collaborative creation of puns. In this system, the pun generator is integrated with a graphical user interface based on a dynamic graph, helping the exploration of different creative solutions.

The present work is only a step of a longer research started in 2001 in the areas of affective computing and computational humor. From the beginning, the main interest was on the creative use of language, the connection between words and emotions, and their computational treatment. In the last years we developed several resources in which some if the ideas presented in this thesis took shape.

One such resource, WordNet-Affect (the affective extension of WordNet described in section 4.3), was adopted by several research groups over the world. It was mainly employed for sentiment analysis and textual affect sensing. The possible reason of the wide interest on this resource is in some characteristics according to which the general structure and the annotation scheme were defined. One is the distinction between *direct affective words* (i.e. words directly referring to emotional states, such as 'joy' or 'fear') and *indirect affective words* (in practice, all the others), inspired by the approach of OCC (Ortony et al., 1988).

Another feature is the classification of emotional categories, concepts, and words according to the values of emotional valence. The emotion words were used as seed words for the automated classification of a larger set of affective words.

To sum up, the research has produced these results:

i Development of WordNet-Affect, a lexical database of affective words and concepts, as documented in (Valitutti et al., 2004; Strapparava and Valitutti, 2004).

ii Development of Affective-Weight, a function for the lexical affect sensing, as documented in (Valitutti et al., 2005; Strapparava et al., 2006; Valitutti et al., 2007).

iii Development of a pun generator based on the humorous variation of familiar expressions, documented in (Strapparava and Valitutti, 2006; Strapparava et al., 2007; Valitutti and Stock, 2007a,b; Stock et al., 2007; Valitutti et al., 2008; Stock et al., 2008).

iv Exploratory experiment with the pun generator for the study of the correlation between lexical properties of texts and humorous effect.

v Development of GraphLaugh, a tool for the interactive creation of humorous expressions. It is an extension of the pun generator, enriched with a graphical user interface consisting of a dynamic interactive graph. Documented in (Valitutti et al., 2009).

vi Development of a hierarchical planner for the adaptive assistance to the execution of complex tasks. The tool can adapt to the emotional state of the user. It was developed for a future integration with the humor generator, in order to achieve reduction of users frustration. Documented in (Valitutti, 2009).

7.2 Future research

Computational treatment of humor is an intriguing opportunity, for both scientific and technological reasons. Nevertheless this emerging area needs new ideas and resources for its development. The present thesis is a contribution in this direction, and it presents a testbed useful for investigating the connections between language and humor processing.

On one hand, humor is a complex cultural phenomenon whose richness cannot be fully simulated with an automatic generation system. It is the evolutionary product of a social and communicative environment. On the other hand, it has some basic characteristics that are recognizable and that can be exploited from a computational point of view. Humor is a collection of phenomena, though, and it makes sense to focus just on some specific types of humor.

An important issue to highlight is that research on humor remains remarkably incomplete if individual differences are not considered. Irrespective of whether jokes are created by humans or a computer program, they will not always find an appreciative audience. It is important to consider a fit to the targeted recipient. Thus, a crucial and feasible direction is the personalization of the humorous message, taking into account some kind of user profiling (such as personal characteristics, interests, but also contextual aspects such as position, weather etc.). Regarding personal characteristics we recall Willibald Ruch's work about humor appreciation and personality (Ruch, 1998). While his study was not developed with computational intent, we believe it can be profitably and realistically exploited also in the implementation of an adaptive computational humor system.

Besides this point, the present work can be further developed in many aspects. Let us briefly review them below.

7.2.1 Possible advancements

The tool can be improved in each of its key functionalities. The procedure for the measure of phonetic distance can be used in the context of other strategies for inducing the recognition of familiar expressions, for instance through the identification of right-side or left-side rhymes, varying more than one word, or taking into account a wider range of phonetic wordplays. New semantic constraints can be integrated. Specific types of semantic dimensions can be tuned in such a way as to perform different types of humor. For example, some words can refer to ridiculous personal traits and then be used to make fun of someone.

Another possible direction is in the generalization of current functionalities in a way to design more general and effective humor generators. For example, the notion of "familiar expression" can be extended to include not only elements of common-sense knowledge, but also expressions there are recognizable because part of the previously presented part of a story or a conversation. In the context of dialogue, the lexical variation can be employed in the simulation of misunderstanding or spoonerisms for humorous purpose. Works on punning riddles (Binsted and Ritchie, 1994) and anaphoric puns (Tinholt and Nijholt, 2007) emphasized respectively lexical and anaphoric ambiguity and can be taken into account.

7.2.2 Measures of incongruity and arousal

The tool can be employed in cognitive studies of humor processing. In a first phase, puns generated by the system can be used as stimuli for measuring the two basic cognitive variables of the appraisal process of most humorous events (i.e. incongruity and playfulness). Particularly interesting is the possibility of employing electroencephalography (EEG), and specifically N400 event related potential on which there is evidence of a correlation with the perception of linguistic incongruity. A hypothesis is that the phonetic distance and the familiarity of the original expression can induce incongruity perception. Incongruity is not necessarily funny, and experiments can help shed light on the role of specific semantic constraints devoted to the induction of humor appreciation.

In a second phase, the investigation can be focused on the correlation between appraisal variables and the two basic affective dimensions of arousal and valence. In particular, the connection between incongruity and arousal is crucial. Measures of arousal can be performed with physiological (e.g. skin conductance) or neurophysiologic and neuroimaging techniques, e.g. EEG or functional Magnetic Resonance Imaging).

7.2.3 Appropriateness and Bayesian approach

The tuning of lexical parameters of the pun generator can increase, to some extent, the probability of humorous effect.

Even human beings, when telling a good joke, cannot be confident of making people laugh. One reason is that the social context is generally as important as the textual content. To produce effective humorous utterances, people need to have a recipients model representing personal traits, values, beliefs, and emotions. The model has to be able to adapt to the changing of these characteristics over time. For this reason, the interactive and conversational aspects are crucial.

In the context of pragmatics, the textual content of a humorous expression is only part of a "humorous act'. The central issue is the analysis of the pragmatic conditions that make the humorous act effective (i.e. capable of inducing the humorous effect with a significantly high probability), and first of all *appropriateness* (Nijholt, 2007). A situation can be defined *appropriate* if it is suitable for the utterance of a humorous act. It is important to emphasize that the definition of humor probability as humorous rank, provided in this thesis, can be the support for the operative definition of *effectiveness* of a humorous act and, therefore, of appropriateness. Given a set of humorous jokes or puns, only some of them are suitable to be uttered in the current situation. Focusing on pun generation, this implies that it has to be combined with a measure of appropriateness.

One idea is to base it on Bayesian networks. In the exploratory experiment described in section 5.2, we adopt a measure of probability of humorous effect (i.e. *humorous rank*) based on the frequentist definition of probability. We can conceive a Bayesian network whose nodes can be included to represent both textual and pragmatic information. In this model, humorous rank has an important role because it can be employed as *prior probability* in the Bayesian inference. *Posterior probability* can be associated, through a fixed threshold, to the appropriateness. For a given situation, if this value overcomes the threshold, the humorous act is recognized as appropriate, and then the expression is uttered.

Appendix A

Papers published during the present research

A. Valitutti (2010). Computational Pun Generation and Control of Humorous Effect. Proceedings of the *Workshop of the Australian Humor Studies Network (AHSN 2010)*, Sydney, Australia.

A. Valitutti, O. Stock, and C. Strapparava (2009). GraphLaugh: a Tool for the Interactive Generation of Humorous Puns. Proceedings of the *System Demo Session at 2009 International Conference of Affective Computing and Intelligent Interaction*, Amsterdam, The Netherlands.

A. Valitutti (2009). Action Decomposition and Frustration Regulation in the Assisted Execution of Difficult Tasks. Proceedings of the AIE*D 2009 Workshop "Closing the Affective Loop in Intelligent Learning Environments"*, Brighton, UK.

O. Stock, C. Strapparava, and A. Valitutti (2008). Ironic Expressions and Moving Words. *International Journal of Pattern Recognition and Artificial Intelligence (IJPRAI).*

A. Valitutti, C. Strapparava, and O. Stock (2008). Textual Affect Sensing for Computational Advertising. Proceedings of the *AAAI Spring Symposium on Creative Intelligent Systems*, Stanford University, Palo Alto, California.

A. Valitutti, C. Strapparava, and O. Stock (2007). Automated Sensing of Affective Lexicon. Proceedings of *"Giornata di Studio sulle Emozioni"*, Padova, Italy.

O. Stock, C. Strapparava, and A. Valitutti (2007). Moving Creative Words. Proceedings of the *2nd International Symposium on Brain, Vision and Artificial intelligence (BVAI 2007)*, Naples, Italy.

C. Strapparava, A. Valitutti, and O. Stock (2007). Affective Text Variation and Animation for Dynamic Advertisement. Proceedings of the *2nd International Conference on Affective Computing and Intelligent Interaction (ACII2007)*, Lisbon, Portugal.

C. Strapparava, A. Valitutti, and O. Stock (2007). Words not Cast in Stone. Proceedings of the *10th Congress of Italian Association for Artificial Intelligence (AI*IA 07)*, Rome, Italy.

C. Strapparava, A. Valitutti, and O. Stock (2007). Automatizing Two Creative Functions for Advertising. Proceedings of the *4th International Joint Workshop on Computational Creativity*, University of London.

C. Strapparava, A. Valitutti, and O. Stock (2007). Dances with words. Proceedings of the *20th International Joint Conference on Artificial Intelligence (IJCAI-07)*, Hyderabad, India.

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A. Valitutti, C. Strapparava, and O. Stock (2004). Developing Affective Lexical Resources. *PsychNology Journal*, 2(1).

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