A Little Metatheory: Thoughts on What a Theory of Computational Humor Should Look Like

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Abstract

This exercise in metatheory presents what any theory consists of and what properties it should have. It, then, adjust the general recipe to a theory of humor and computational humor. In this light, it reviews the state of the art in computational humor and suggests the main lines of development.

Why bother with a theory?

Isn't this a silly question, though? A theory is a good thing to have, isn't it? It renders an area of research some prestige, makes it respectable, established. If there is more than one theory they can be compared and argued about. (That can be done only with the help of a metatheory, by the way.) But other than an ornament, is a theory necessary? Can it help with the actual research? I don't think there are many scholars in any field who think they need a theory, even though they may routinely use a certain methodology. This scholar does need a theory, cannot make a step without forming or questioning one, and thinks that proceeding without a theory is doomed.

Arguing for the necessity of a theory for computational humor in order to advance artificial intelligence with regard to this important human faculty that forms a part of our communicative competence is the main thrust of this paper. In the next section, we will discuss what a theory is, what it does, and why it is important. In the following section, we will apply this to computational humor and the artificial intelligence of humor (by that time, we will try and figure out whether those two are the same or different). And in the final section, before the conclusion, we will try and figure out what the agenda of computational humor research should be when it grows up. The main thrust of the paper is to allay this author's fear that we are preventing a focused and expedient progress in the field by proceeding in a blind fashion, without a clear vision, discussed and negotiated by the community, about such important issues as priorities, feasibility, and applications.

Reasons for explicit theorizing

Over a decade ago, this author contributed a chapter to Nirenburg and Raskin (2004: Ch. 2). It was written in desperation: for reasons outlined below as well as some others, a theory needed to be built, and the philosophy of science which, one would think, should have developed a set of recommendation on how to do it right, had been—and has been—completely silent on the subject. So I proceeded with an imaginary DIY kit. Some of the results still hold; others have been revised, updated, and upgraded.

I still believe in the theory-methodology-results triple. Theory determines the format of the results, and it licenses methodologies for obtaining these results. Theory also enables and ensures optimization, scalability, extent of generalization, bias detection, evaluation, standardization, reusability, and last but not least, explanation hypotheses.

The structure of a theory

Every theory includes at least these 5 components

- **Body of the Theory:** set of explanatory and predictive statements about its purview;
- **Purview:** the phenomena that the theory takes on itself to deal with, or what it is the theory of;
- **Premises**: the implicit axiomatic statements that the theory takes for granted—these are not stated clearly by many theories and cause most misunderstanding;
- **Goals**: the final results of the successful formulation of a theory;
- Methods of **falsification**: the clearly stated hypothetical situation which would prove the theory wrong, a counterexample—we follow here

Popper's (1972) view that a hypothesis that is unfalsifiable in principle is not only not a theory but is actually a faith;

- Method **of justification/evaluation**: a set of statements on how to check the veracity of the body statements and, wherever possible, on how to compare the theory to its competition, if any.

Of all of these components, the body is the most obvious or at least visible one while the premises are very rarely stated, explicated, discussed, or defended—because they are "obvious" to a community of scholars. This neglect leads to narrow, partisan approaches that are rarely scalable or reusable

The properties of a theory

A well-developed, mature, self-aware, and therefore usable computational theory is characterized by all the properties below—it must be and actually is:

- **adequate**, if it provides an accurate account of all the phenomena in its purview;
- **effective**, if it comes with a methodology for its implementation;
- **formal,** if it submits itself to logical rules, whether it does or does not use a specific formalism--confusing formality with formalism is one of the worst and unfortunately common offenses in discussing a formal theory;
- **constructive**, if that implementation can be completed in finite time;
- **decidable**, if there is an algorithm for its implementation in principle;
- **computable**, if this algorithm can actually be demonstrated,
- **explicit**, if it is fully aware of all of its components and provides a full account of each of them.

The structure of an optimal theory of computational humor

What is then, in the light of the previous section, an optimal theory of computational humor? Do we have it, and if so, what are its components? Computational humor is humor, so it is natural to check first how the metatheory applies to a theory of humor.

Components of linguistic theories of humor

Since it has only been applied (Raskin 2012) to the SSTH-GTVH-OSTH dynasty of linguistic theories of humor (Raskin 1985; Attardo and Raskin 1991; Raskin et al. 2009; see also Raskin 2012), let us look in there. The components that these theory share have been:

- **body**: the main hypothesis that the text of a (potential) joke is compatible, in full or in part, with two opposing scripts;
- **purview:** textual humor, most easily applicable to short canned jokes;
- **premises**: mostly that a text can be recognized as humor-carrying in the process of normal linguistic semantic analysis within a certain approach and understood the way humans do;
- **goals**: mostly to account for how each joke works, which amounts to understanding it the way people do and going beyond that to a full explanation, the way people don't;
- **falsification**: a joke that is not based on overlapping and opposed scripts—not yet produced, it appears; and
- **justification**: see Ruch et al. (1993) on a successful psychological experiment that bore out most of the GTVH claims.

Let us now extend the above bullets to a theory of computational humor.

Components of a computational theory of humor

This is how a computational theory of humor based on the SSTH-GTVH-OSTH theories adjust or reinterprets the components:

- **body**: the main hypothesis that the text of a (potential) joke is compatible, in full or in part, with two opposing scripts and that a computational system based on this hypothesis is possible that can detect, comprehend, and generate humor;
- **purview:** verbal humor; meaning processing algorithms, humor detection and generation algorithms;
- **premises**: mostly that a text can be recognized as humor-carrying in the process of normal linguistic semantic analysis, within a certain approach, and understood the way humans do, and that this process can be performed by a computational system;
- **goals**: to develop scalable and reusable computational system for a growing number of real-life applications, such as shut-in companions (Wilks 2005) and social computing;
- **falsification**: interestingly, a failure to develop such a computational system will not amount to falsification—real falsification will require proof that, for any such system, a false result will be produced; and
- **justification**: this will require an experiment with human raters of the produced results.

Properties of theories of computational humor

As we stated elsewhere (Raskin et al. 2009), only when the latest phase in the linguistic theories of humor, the Ontological Semantic Theory of Humor, has been reached, the desirable properties of a computational humor have become feasible to achieve. This is how they are modified for theories of computational humor:

- **adequate**, if it provides an accurate account of all the phenomena in its purview in computational implementations;
- **effective**, if it comes with a computational methodology for its implementation;
- **formal,** trivial because any miscalculation in formality will result in systemic failure;
- **constructive**, if that implementation can be computationally completed in finite time—an issue of computational complexity of the system;
- **decidable**, if there is a computational algorithm for its implementation in principle;
- **computable**, if this algorithm can actually be implemented,
- **explicit**, if it is fully aware of all of its components and provides a full account of each of them, which should be trivially achieved in a functional computational system.

Let us now compare this optimal theory of computational humor with the reality on the ground.

Past, present, and future of computational humor

This Symposium needs less introduction to the field, so I will keep it brief. The usefulness and motivations of computational humor have been intensely discussed (Raskin & Attardo 1994, Binsted 1995, Raskin 1996, Ritchie 2001, Mulder & Nijholt 2002, Nijholt 2002, Raskin 2002, Stock & Strapparava 2002, Binsted et al., 2006, Hempelmann 2008), with applications varying from friendlier computer systems and human-computer interfaces (Morkes et al. 1998, Nijholt 2002, Binsted 1995, Binsted at al. 2006) and more effective communication (Lyttle 2001) to education (McKay 2002, O'Mara & Waller 2003, Waller et al. 2005) and “edutainment” (Stock 1996), to advertising, politics and commerce (Raskin 2002, Stock & Strapparava 2006), to information security (Raskin 2002), to detection of unintended humor (Raskin 2002, Stock & Strapparava 2002, Taylor & Mazlack 2005b). It can also be important to detect and exclude humor from reporting it as accurate information because humor is, in principle, not commited to the literal truth of the statements (Taylor 2008).

Accepting that computational humor is important, the question of its feasibility arises. Several humor generators (Raskin & Attardo 1994, Binsted & Ritchie 1994, Binsted 1996, Ritchie et al. 2006, Lessard & Levison 1992, McDonough 2000, Stock & Strapparava 2002, 2005, McKay 2002, Hempelmann 2003, Taylor & Mazlack 2005a) and fewer computational humor recognizers/detectors (Taylor & Mazlack 2004, Mihalcea & Strapparava 2005, 2006, Mihalcea & Pulman 2007, Mihalcea et al. 2010, Taylor 2008) have been attempted.

Computational generators of humor that have been tried are mostly template-based, limited to the generation of a narrow joke type, and mostly free from humor theory. The templates contain enough information for their syntactic structure not to have to be computationally verified—it is a given. The generators do not fully generate sentences but rather fill in the blanks with appropriate words in a way that sometimes results in humor. While these generators may provide interesting and entertaining results, they are far from being usable for quality interaction.

Computational detectors do not have the luxury of templates to rely on, although such highly formulaic texts as the Knock Knock jokes (Taylor 2004) have been tried. To compensate for the lack of templates, machine learning classification methods have been used to separate texts into humorous and non-humorous subsets, with a possible analysis of the contrastive features (Mihalcea & Strapparava 2005, 2006, Mihalcea & Pulman 2007). These results, while impressive, have not, however, led to any insights into the nature or structure of verbal jokes. Semantic methods, tightly associated with humor theories, tend to be more illuminating in this respect (Taylor 2008), but still emphasize the distinctions between jokes and non-jokes rather than the constitutive features of the former, including optimality or even elegance.

The small number of the attempts is partly due to the difficulty of accessing a context sensitive, computationally based world model (Taylor 2008). Such difficulties are eliminated when the humor analysis is done with a system capable of capturing the semantics of text (Raskin 2008b; Raskin et al. 2009a,b; Taylor 2010b). The computational humor ventures also have exposed a two-fold dependency between the underlying theories of humor and their computational implementations that feed on, motivate, and justify each other.

The low-hanging fruit in computational humor has been toy systems for generating formulaic humor, based on filling in the gaps in templates. As I argued in Raskin (1996), these do not provide either any innovations in linguistic technologies nor any insight into the nature of humor. One major reason for that is that they are not meaning-based and, therefore, not scalable.

We are not alone in having taken that path first. While it is a dead end, it has the initial appeal of media attention, which invariably focuses on the wrong points and misstates the achievement, if any, it also recruits some good scholars. The initial method-driven, imitative, regurgitative approach can be seen, in a positive light, as reconnaissance through a low-scale military action: instead of sending a bunch of scouts to penetrate the enemy's position and to capture a prisoner for interrogation on logistic factors, enemy troops are engaged by an attack in hope that the positions, locations, and resources will be revealed. But wars and even battles can only be won in the problem-driven way, using a variety of methods. The problem-driven approach rides on an adequate theory.

The practical stimulus to the development of any field is resources—read money. And funding is available only for applications. So I believe that *the first order of the day is to identify applications, where humor analysis and generation are essential*. I have already mentioned the shut-in companion and, generally, social computing applications what else is there? What the field needs is middle-to-large-scale corpora of text, for which it is necessary to separate humor from non-humor. Social network postings, chats, and comments, and even tweats mix humor with serious stuff, and I think it is likely that funding will be more available for excluding humor from processing—for instance, in cybersecurity, where facetious references to future attacks should be ignored, and similarly so, the intercepts of military communications by the enemy personnel. If those have references to a million tanks that will have to be produced on the battleground by next Tuesday, they have to be ignored.

The other major direction is to place computational humor research on a full meaning-based approach. Ontological Semantic Technology is only one possible approach, which happens to be the first historically. At the core of OST (Nirenburg & Raskin 2004, Raskin et al. 2010b, Hempelmann et al. 2010, Taylor et al. 2010a) are repositories of world and linguistic knowledge, acquired semi-automatically within the approach and used to disambiguate the different meanings of words and sentences and to represent them comprehensively. These repositories, also known as the static knowledge resources, consist of the ontology, containing language-independent concepts and relationships between them; one lexicon per supported language (English, Russian, Arabic, etc), containing word senses anchored in the language-independent ontology which is used to represent their meaning; and the onomasticon, which contains names of people, countries, organizations, etc., and their descriptions, also anchoring them in ontological concepts and interlinking them with its other entries. The lexicon and ontology are used by the semantic analyzer, a software that produces text meaning representations (TMRs) from the text that it reads. The format of TMRs conforms to the format and interpretation of the ontology. The processed TMRs are entered into the information repository, a dynamic knowledge resource of OST, from which information is used for further processing and reasoning. Partial components of the system (Taylor et al. 2010a,b,c; Taylor et al. 2011b; Raskin et al. 2010b; Hempelmann et al. 2010) as well as its ability to handle similar texts (Taylor 2010a) have produced successful results. Some progress has been reported on the thorny semantic issues with English compound nominals (Taylor et al. 2010c) and on the OST robust treatment of unattested input (Taylor et al. 2011c; Taylor & Raskin 2011b). Even more recently, OST moved into robotic intelligence (Matson et al. 2011), and cognitive science (Hempelmann et al. 2012), areas to which computational humor is also highly pertinent. And OSTH has progressed since Raskin et al. (2005, 2009)—see, for instance, Raskin (2011, 2012) and Taylor (2011, 2012).

The OST approach should not exclude the statistical and machine learning approaches to computational humor. There are some direction in OST, where the current knowledge is still insufficient to serve as a basis for deterministic rule-based systems—for instance, complex probabilistic inferencing and fuzzy reasoning. I believe, however, that these methods should apply to the TMRs rather than to raw text or, at the very least, to deep-semantically-tagged corpora.

Needless to say, approaching computational humor while equipped with the full-fledged theory as described in the previous section, does not mean going for the full- and large-scaled projects. These should be sized to fit the applications as long as the scalability is assured.

Conclusion

In this brief statement, I outlined a problem-driven theory-based approach to computational humor. After presenting a view of what such a theory is in general and then adjusting it to an ideal theory of computational humor, I outlined where I think the field should be moving. We will see how it plays out in reality.

References

Attardo, S. (1994). *Linguistic Theories of Humor.* Berlin and New York: Mouton de Gruyter.

Attardo, S., & Raskin, V. (1991). Script theory revis(it)ed: joke similarity and joke representation model. *Humor: International Journal of Humor Research 4*(3-4): 293-347.

Binsted, K. (1995). Using humour to make natural language interfaces more friendly. *Workshop on AI, A Life and Entertainment, International Joint Conference on Artificial Intelligence.* Montreal, Canada.

Binsted, K. (1996). *Machine Humour: An implemented model of puns*. Ph.D. Dissertation, University of Edinburgh, Edinburgh, Scotland, UK.

Binsted, K., & Ritchie, G. (1994). An implemented model of punning riddles. *Proceedings of the Twelfth National Conference on Artificial Intelligence.* Seattle, WA.

Binsted, K., Bergen, B., Coulson, S., Nijholt, A., Stock, O., Strapparava, C., Ritchie, G., Manurung, R., Pain, H., Waller, A., & O'Mara, D. (2006). Computational Humor. *IEEE Intelligent Systems (special sub-issue)* 21.

Hempelmann, C. F. (2003). *Paronomasic Puns: Target Recoverability Towards Automatic Generation.* Ph. D. Thesis, Linguistics Program, Purdue University, West Lafayette, Indiana.

Hempelmann, C. F. (2008). Computational humor: Going beyond the pun. In V. Raskin (ed.), *The Primer of Humor Research,* Berlin-New York: Mouton de Gruyter, 333-360.

Hempelmann, C. F., Taylor, J. M., & Raskin, V. (2010). Application-guided Ontological Engineering. *Proceedings of the International Conference on Artificial Intelligence,* Las Vegas, NE.

Hempelmann, C. F., Taylor, J. M., & Raskin, V. (2012). Tightening up joke structure: Not by length alone. CogSci '12: Annual Meeting, Cognitive Science Society, Sapporo, Japan.

Lessard, G., & Levison, M. (1992). Computational modeling of linguistic humour: Tom Swifties. *ALLC/ACH Joint Annual Conference*, Oxford, UK, 175-178.

Lyttle, J. (2001). The effectiveness of humor in persuasion: The case of business ethics training. *Journal of General Psychology* 128(3): 206-216.

Matson, E. T., Taylor, J. M., Raskin, V., Min, B.-C., & Wilson, E. (2011). A natural language model for enabling Human, Agent, Robot and Machine interaction, *The 5th IEEE International Conference on Automation, Robotics and Applications,* Wellington, New Zealand.

McKay, J. (2002). Generation of idiom-based witticisms to aid second language learning. In O. Stock, C. Strapparava, & A. Nijholt (eds.), *The April Fools' Day Workshop on Computational Humor*, Trento, Italy: ITC-irst, 77-87.

Mihalcea, R., & Pulman, S. (2007). Characterizing humour: An exploration of features in humorous texts. *Lecture Notes in Computer Science 4394*: 337-347. Berlin: Springer.

Mihalcea, R., & Strapparava, C. (2005). Computational laughing: Automatic recognition of humorous one-liners. *Proceedings of Cognitive Science Conference*, Stresa, Italy, 1513-1518.

Mihalcea, R., & Strapparava, C. (2006). Learning to laugh (automatically): Computational models for humor recognition. *Computational Intelligence 22* (2): 126-142.

Mihalcea, R., Strapparava, C., & Pulman, S. (2010). Computational models for incongruity detection in humor. *Proceedings of the Conference on Computational Linguistics and Intelligent Text Processing (CICLing 2010)*, Iasi, Romania.

Morkes, J., Kernal, H. K., & Nass, C. (1998). Humor in task-oriented computer-mediated communication and human-computer interaction. *Proceedings of CHI.* New York: ACM.

Mulder, M. P., & Nijholt, A. (2002). Humour research: State of the art. Enschede, Netherlands: University of Twente.

Nijholt, A. (2002). Embodied agents: A new impetus to humor research. In O. Stock, C. Strapparava, & A. Nijholt, eds., *The April Fool's Day Workshop on Computational Humor,* Trento, Italy: ITC-irst, 101-111.

Nirenburg, S., & Raskin, V. (2004). *Ontological Semantics.* Cambridge, MA: MIT Press.

O'Mara, D., & Waller, A. (2003). What do you get when you cross a communication aid with a riddle? *The Psychologist* 16 (2): 78-80.

Raskin, V. (1985). *Semantic Mechanisms of Humor.* Dordrecht: Reidel.

Raskin, V. (1996). Computer implementation of the General Theory of Verbal Humor. In J. Hulstijn, & A. Nijholt, eds., *The International Workshop on Computational Humour*, 9-19. Enschede: UT Service Centrum.

Raskin, V. (2002). Quo vadis computational humor? Computational humor and ontological semantics. In O. Stock, C. Strapparava, & A. Nijholt, eds., *The April Fool's Day Workshop on Computational Humor*, Trento, Italy: ITC-irst, 31-46.

Raskin, V. (ed.) (2008c). *The Primer of Humor Research.* Berlin-New York: Mouton de Gruyter.

Raskin, V. (2011). Length and saliency of jokes. In: P. Oppliger (ed.), *Abstracts of ISHS '11, the 2011 Annual Meeting of the International Society of Humor Studies*, Boston University, Boston, MA,.

Raskin, V. (2012). Humor theory's purview: What is reasonable to expect from a theory of humor. Plenary address, ISHS '12: International Conference on Humor Research, Jagellonian University, Cracow, Poland.

Raskin, V., Hempelman, C. F., & Taylor, J. M. (2009a). How to understand and assess a theory: The evolution of the SSTH into the GTVH and now into the OSTH, *Journal of Literary Theory* 3(2), 285-312.

Raskin, V., Hempelmann, C. F., & Taylor, J. M. (2009b). Symposium 'From SSTH to GTVH to OSTH—and never ever back!' *2009 Annual Meeting of the International Society for Humor Studies—ISHS'09: International Conference on Humor Research*, Long Beach, CA: University of California.

Raskin, V., Hempelmann, C. F., & Taylor , J. M. (2010b). Guessing vs. knowing: The two approaches to semantics in natural language processing, *Annual International Conference Dialogue 2010*, 642-650, Bekasovo (Moscow), Russia.

Raskin, V., Hempelmann, C. F., & Taylor , J. M. (2012). Ontological Semantic Theory of Humor. A Pre-Conference Tutorial, ISHS '12: International Conference on Humor Research, Jagellonian University, Cracow, Poland.

Raskin, V., Hempelmann, C. F., & Triezenberg, K. E. (2006). Computer, tell me a joke ... but please make it funny: Computational humor with Ontological Semantics. In G. Sutcliffe & R. Goebel (eds.), *Proceedings of the 19^{th} FLAIRS Conference*, Melbourne Beach, FL: Florida Institute of Technology.

Ritchie, G. (2000). Describing verbally expressed humour. *Proceedings of AISB Symposium on Creative and Cultural Aspects and Applications of AI and Cognitive Science*, Birmingham, UK, 71-78.

Ritchie, G. (2001). Current directions in computational humour. *Artificial Intelligence Review , 16*(2): 119-135.

Ritchie, G., Manarung, R., Pain, H., Waller, A., & O'Mara, D. (2006). The STANDUP Interactive Riddle Builder. *IEEE Intelligent Systems, 21*(2): 67-69.

Ruch, W., Attardo, S., & Raskin, V. (1993). Toward an empirical verification of the General Theory of Verbal Humor. *Humor: International Journal of Humor Research* 6(2): 123-136.

Stock, O. (1996). Password Swordfish: Verbal humor in the interface. In J. Hulstijn & A. Nijholt (eds.), *Proceedings of the International Workshop on Computational Humour (TWLT 12)*, University of Twente, Enschede, Netherlands.

Stock, O., & Strapparava, C. (2002). HAHAcronym: Humorous agents for humorous acronyms. In O. Stock, C. Strapparava, & A. Nijholt (eds.), *The April Fools' Day Workshop on Computational Humor*, 125-135.

Stock, O., & Strapparava, C. (2005). The act of creating humorous acronyms. *Applied Artificial Intelligence, 19*(2): 137-151.

Stock, O., & Strapparava, C. (2006). Automatic production of humorous expressions for catching the attention and remembering. *IEEE Iintelligent Systems*, 64-67.

Stock, O., Strapparava, C., & Nijholt, A. (eds.) (2002). *The April Fools' Day Workshop on Computational Humor*, Trento & Enschede: ITC-irst & University of Twente, 125-135.

Taylor, J. M. (2004). *Computational Recognition of Humor In A Focused Domain.* M. S. Thesis, Department of Electrical, and Computer Engineering and Computer Science, University of Cincinnati: Cincinnati, OH.

Taylor, J. M (2008). *Towards Informal Computer Human Communication: Detecting Humor in Restricted Domain*, Ph. D thesis, Department of Electrical and Computer Engineering, University of Cincinnati, 2008.

Taylor, J. M. (2010). Ontology-based view of natural language meaning: The case of humor detection, *Journal of Ambient Intelligence and Humanized Computing 1*(3):221-234.

Taylor, J. M. (2011). Does SO2 always result in a joke: How long is long enough?" Symposium/Panel on the Length of Jokes. In P. Oppliger (ed.), *2011 Annual Meeting of the International Society for Humor Studies—ISHS'11: International Conference on Humor Research*, Boston, MA: Boston University.

Taylor, J. M. (2012). OSTH in action: Comparison of 50 jokes. ISHS '12: International Conference on Humor Research, Jagellonian University, Cracow, Poland.

Taylor, J. M., Hempelmann, C. F., & Raskin, V. (2010a). On an automatic acquisition toolbox for ontologies and lexicons in Ontological Semantics, *International Conference on Artificial Intelligence,* Las Vegas, NE.

Taylor, J. M., & Mazlack, L. J. (2004). Computationally recognizing wordplay in jokes. *Proceedings of Cognitive Science Conference.* Chicago.

Taylor, J. M., & Mazlack, L. J. (2005a). Focused statistical joke generation, *2005 International Conference on Artificial Intelligence*, Las Vegas, NE.

Taylor, J. M.. & Mazlack, L. J. (2005b). Toward computational recognition of humorous intent, *Cognitive Science Conference 2005,* Stresa, Italy.

Taylor, J. M., & Raskin, V. (2011). Understanding the unknown: Unattested input processing in natural language. *FUZZ-IEEE Conference*, Taipei, Taiwan

Taylor, J. M., Raskin, V., Hempelmann, C. F., & Vandiver, W. R. (2010b),. Computing the meaning of number expressions in English: The common case. *Intelligent Linguistic Technologies Workshop*, *International Conference on Artificial Intelligence,* Las Vegas, NE.

Taylor, J. M., Raskin, V., & Hempelmann, C. F. (2011b). From disambiguation failures to common-sense knowledge acquisition: A day in the life of an Ontological Semantic System. *Web Iintelligence Conference*, Lyon, France.

Taylor, J. M., Raskin, V., & Hempelmann, C. F. (2011c). Towards computational guessing of unknown word meanings: The Ontological Semantic approach. *Cognitive Science Conference*, Boston, MA.

Waller, A., O'Mara, D., Manurung, R., Pain, H., & Ritchie, G. (2005). Facilitating user feedback in the design of a novel joke generation system for people with severe comminication impairment. *International Conference on Human-Computer Interaction.* Las Vegas, NE.

Wilks, Y. 2005. Artificial companions. *Interdisciplinary Science Reviews* 30 (2) 145-152.