Sarcastic fringehead
*Neoclinus blanchardi*

# INDIVIDUAL DIFFERENCES IN PROCESSING WRITTEN IRONY

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*To my son Urho*

## Tiivistelmä

Ironian ymmärtämisen teorioiden mukaan ironisen lausahduksen merkityksen ratkaiseminen kestää pidempään kuin saman lausahduksen prosessointi kirjaimellisessa merkityksessä, mikäli lausahdus ei ole entuudestaan tuttu ja jos sitä ei ole voinut ennakoida. Tämän hidastumisen ajatellaan heijastavan virkkeen uuden merkityksen liittämistä aiempaan tekstikontekstiin, mikä edellyttää virkkeen uudelleen prosessointia. Muiden kuvaannollisen kielen muotojen, kuten metaforien, merkityksen ymmärtämisen on oletettu tapahtuvan samankaltaisen prosessin kautta. Lisäksi pitkään on oletettu, että terveet aikuiset ymmärtävät ironiaa samalla tavoin. Viimeaikaiset tutkimukset ovat osoittaneet, että eri kuvaannollisen kielen muotojen ymmärtäminen edellyttää lukijalta erilaisia kognitiivisia taitoja. Lisäksi viimeaikaiset tutkimustulokset antavat viitteitä siitä, että ironian ymmärtämisessä on yksilöllisiä eroja, jotka voisivat liittyä työmuistin kapasiteettiin ja emotionaalisen tiedon prosessointikykyyn. Tässä tutkielmassa halusin selvittää: 1) kuinka lukijat ratkaisevat ironisen lausahduksen merkityksen, 2) kuinka yksilölliset erot työmuistin kapasiteetissa ja emotionaalisen informaation prosessoinnissa vaikuttavat ironian prosessointiin ja 3) kuinka ironian prosessointi eroaa muiden kuvaannollisen kielen muotojen, kuten metaforien, prosessoinnista. Näitä tutkimuskysymyksiä selvitettiin neljässä osatutkimuksessa silmänliikemenetelmän avulla. Menetelmän avulla on mahdollista seurata reaaliajassa ymmärtämisprosessin etenemistä. Tutkielman tulokset osoittavat, että lukijat prosessoivat ironisen virkkeen uudelleen ymmärtääkseen sen tarkoitetun merkityksen. Työmuistin kapasiteetti auttaa tässä prosessissa joko auttamalla lukijoita pitämään mielessään konteksti-informaatiota, jotta he voivat integroida uuden merkityksen siihen, tai auttamalla lukijoita torjumaan ironisen lausahduksen kirjaimellisen merkityksen tulkintaprosessin aikana. Emotionaalisen informaation prosessointikyky auttaa lukijaa tunnistamaan ironisen kommentin emotionaalisen viestin; ne lukijat joiden emootioiden prosessointikyky on heikko, joutuvat tulkintaa tehdessään nojaamaan enemmän kontekstissa esitettyihin vihjeisiin. Tutkimuksen tulokset osoittavat myös, että ironian prosessointi eroaa metaforien prosessoinnista. Metaforat ovat helpompia ymmärtää ja niiden merkityksen prosessointi alkaa varhaisemmassa vaiheessa. Lisäksi emotionaalisen informaation prosessointikyky liittyy vain ironian prosessointiin. Tämän tutkielman löydöksiin perustuen esitän uuden teoreettisen viitekehyksen ironian ymmärtämiseen, *kumuloituvien todisteiden mallin*.

Avainsanat: ironia, sarkasmi, metafora, kuvaannollinen kieli, silmänliikkeet, lukeminen, yksilölliset erot, emootio, työmuisti

# Abstract

Theoretical accounts of irony comprehension assume that when an ironic utterance is unfamiliar and the context does not prime for ironic interpretation, processing should take longer than when reading the same utterance with a literal meaning. This slowdown reflects problems in integrating the utterance into the developing text representation, which results in a reanalysis of the utterance. Similar assumptions are made about other forms of figurative language, such as metaphors, although studies have shown that there are differences in the cognitive demands of different forms of figurative language. Until fairly recently, most of the studies have ignored possible individual differences in irony comprehension among healthy adults. Recent results have suggested that there might be individual differences in irony comprehension related to working memory capacity (WMC) and emotion processing. In the present thesis, I wanted to answer the following questions: 1) How do readers resolve the meaning of irony? 2) How do individual differences in WMC and the ability to process emotional information affect the processing of irony? and 3) Does the processing of irony differ from the processing of other forms of figurative language, namely metaphors? These questions were examined in four studies using eye-tracking to tap into the detailed time-course of resolving the meaning of irony. The results of these studies showed that readers need to reprocess the ironic utterance to achieve the intended meaning, as suggested by the theories on irony comprehension. WMC aids this process by helping readers to keep contextual information in their mind while they integrate the meaning of the utterance with the context and/or inhibit a more salient literal interpretation while making the inference. Emotion processing abilities help to recognize the emotional cues of irony; readers with a poorer ability to process emotional information need to rely more on textual context to resolve the ironic meaning. Finally, resolving the ironic meaning differs from resolving other forms of figurative language, namely metaphors. Metaphors are easier to comprehend, and the processing of the intended meaning of metaphors starts at an earlier stage of reading. Moreover, emotion processing abilities are related to the processing of irony, but not metaphors. Based on the findings of this thesis, I present a new theoretical framework, the *Cumulative Evidence Model*.

Keywords: irony, sarcasm, metaphor, figurative language, eye-tracking, reading, individual differences, emotion, working memory

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Turku, December 2018

Henri Olkoniemi

# Table of Contents

# List of original publications

This thesis is based on four original articles. The studies are referred to in the text by the following Roman numerals:

I. Kaakinen, J. K., Olkoniemi, H., Kinnari, T., & Hyönä, J. (2014). Processing of written irony: An eye movement study. *Discourse Processes, 51*, 287–311. *

II. Olkoniemi, H., Ranta, H., & Kaakinen, J. K. (2016). Individual differences in the processing of written sarcasm and metaphor: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*, 433–450. **

III. Olkoniemi, H., Strömberg, V., & Kaakinen, J. K. (2018). The ability to recognise emotions predicts the time-course of sarcasm processing: Evidence from eye movements. *Quarterly Journal of Experimental Psychology.* Advance online publication.***

IV. Olkoniemi, H., Johander, E., & Kaakinen, J.K. (2018). The role of look-backs in the processing of written sarcasm. *Memory & Cognition.* Advance online publication.****

The four original studies are presented in the thesis in the order in which they were submitted for publication. The publications are reproduced in the Appendix of this thesis with the permission of the copyright holders. All rights reserved.

# 1. Introduction

Before going more deeply into the topic of this thesis, I find it important to define irony because it is used loosely in everyday language (e.g., Morissette & Ballard, 1995). A short definition for irony is that it is "a result opposite to what was expected" (*Merriam-Webster Dictionary*, 2017). Irony can be roughly divided into verbal and situational irony (Attardo, 2000; Kumon-Nakamura, Glucksberg, & Brown, 1995). *Situational irony* refers to a state of the world which is perceived as ironic; for example, when a fire station is on fire. *Verbal irony*, on the other hand, can be defined as the use of words to express something other than, and especially intending the opposite of, the literal meaning (Attardo, 2000; *Merriam-Webster Dictionary*, 2017). For example, when Peter's friend Paul finds out that Peter did not donate any money for the new children's hospital, and Paul utters, "You're such a generous person." What Paul means is to criticize Peter's indifference. The present thesis concentrates only on the processing of verbal irony.

The above given dictionary definition on verbal irony is in line with so-called classical view on irony (e.g., Grice, 1975). In the research literature, it is argued that the classical view is too simple and does not capture all the forms of verbal irony (see e.g., Burgers, van Mulken, & Schellens, 2011; Gibbs & Colston, 2007; Wilson & Sperber, 2004). One more nuanced definition, trying to combine the other existing definitions, is that verbal irony is "an utterance with a literal evaluation that is implicitly contrasting the intended evaluation" (Burgers et al., 2011, p. 190). From the point of view of this thesis both of the definitions given above are able to discriminate the ironic materials from the non-ironic ones used across the studies of this thesis.

For the topic of this thesis it is also important to define *sarcasm* because sometimes verbal irony and sarcasm are seen as synonymous (Attardo, 2000; Gibbs & Colston, 2007; Haiman, 1998), even though the Roman rhetorician Quintilian had already differentiated between irony and sarcasm around 2,000 years ago (Quintilian, trans. 1921). In the present thesis, and often in the research literature, sarcasm is defined as a subtype of verbal irony, which differs from the other types

of irony in that sarcasm is used to criticize someone[1] (Attardo, 2000; Haiman, 1998; Kreuz & Glucksberg, 1989). In other words, the essential difference between verbal irony and sarcasm is that sarcasm is aggressive, intentional, and it has a target (Attardo 2000; Haiman, 1998). The example above about Peter and Paul is also an example of sarcasm.

Verbal irony is an integral part of our everyday communication. It is used across cultures[2] (Schwoebel, Dews, Winner, & Srinivas, 2000), occurring on a daily basis in our lives; for example, irony is used approximately eight times per hour in American television shows (Schwoebel et al., 2000). The use of verbal irony has been shown to serve a social role. People often use it to soften criticism and to remind each other that they belong to the same group (Colston, 1997; Dews, Kaplan, & Winner, 1995; Gibbs, 2000; Gibbs & Izett, 2005). It has been shown that about 8% of all language used in conversations between friends is ironic (Gibbs, 2000). Irony is also used as an argumentative tool, and it is used, for example, in political debates (Musolff, 2017; Nuolijärvi & Tiittula, 2011). It has been suggested that people use ironic language more in the written form of computer-mediated communication than in face-to-face conversations, although there is a higher risk of miscommunication (Hancock, 2004).

Although irony is an important element of human communication, there is variability among people's irony comprehension. Thus, the use of irony in communication, for example, in written form on social media sites, can lead to unwanted and unexpected consequences. For example, in 2013, before her flight to Cape Town, Justine Sacco wrote on Twitter, "Going to Africa. Hope I don't get AIDS. Just kidding. I'm white!" Her tweet was taken as an offensive racist comment, and she was eventually fired from her job because of it (Ronson, 2015). She stated afterwards that she did not mean her comment to be racist, or that white people were immune to AIDS; her intention was to make an ironic joke about Americans being unaware of the problems in third-world countries (Ronson, 2015). Because ironic language is at risk of being misunderstood, it has been suggested that it should not be used, for example, in court (Tribler, 2010), in advertisements (Pehlivan, Berthon, & Pitt, 2011), or in education (Wilkins, 1932).

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[1]   There is also so-called positive sarcasm, or ironic praise, where someone states something negative although s/he is giving a compliment (see e.g., Clark & Gerrig, 1984; Gibbs, 2000). For example, Peter donates a huge amount of money to charity, and his friend Paul utters to him, "You're such a horrible person." What Paul means is that he appreciates Peter's gesture. It has been suggested that ironic praise is not used as often in everyday language as ironic criticism, making it a rarer form of irony (see e.g., Clark & Gerrig, 1984; Gibbs, 2000). Hence, it is left out of the scope of this thesis.

[2]   Curiously, Haiman (1998) reports that Hua people, a group in the Eastern Highlands of Papua New Guinea, do not use sarcasm.

Traditionally, it has been thought that only children and patients with neurological and/or psychiatric disorders have deficits in irony comprehension. Irony comprehension is a developing ability that starts when children are around 5–6 years old (Climie & Pexman, 2008; Dews et al., 1996; Glenwright & Pexman, 2010; Pexman, Glenwright, Krol, & James, 2010; see also Recchia, Howe, Ross, & Alexander, 2010), and irony appreciation develops until early adulthood (see e.g., Dews et al., 1996; Glenwright & Pexman, 2010). It has been shown that several neurological and psychiatric conditions are associated with deficits in irony comprehension, for example, brain lesions (e.g., Bohrn, Altmann, & Jacobs, 2012; McDonald, 1999; Rapp Muntschler, & Erb, 2012; Shamay-Tsoory, Tomer, & Aharon-Peretz, 2005), alcoholism (Amenta, Nöel, Verbanck, & Campanella, 2013), autism spectrum disorder (e.g., Happé, 1993), and schizophrenia (Mo, Su, Chan, & Liu, 2008). Because verbal irony comprehension declines with many disorders, it is also used as a diagnostic tool (see e.g., "The Metaphor and Sarcasm Scenario Test", Adachi et al., 2004; "The Awareness of Social Inference Test", McDonald, Flanagan, Rollins, & Kinch, 2006). However, recent experimental findings (Ivanko, Pexman, & Olineck, 2004) and theories on irony comprehension (e.g., Giora, 1999) have suggested that there are also individual differences in verbal irony comprehension among the healthy adult population. The topic remains still largely unexplored. Because deficits in irony comprehension can lead to vast consequences, and irony comprehension ability is used as a diagnostic aid, it is important to understand why there are individual differences in the processing of verbal irony even among the healthy adult population and what makes irony comprehension a challenge to human cognition. Thus, it is the topic of the present thesis.

Next, I will go through the most important theories of irony comprehension. After that, I will go through factors that might cause individual differences in irony comprehension, followed by a discussion on the differences and similarities between irony and metaphors. Finally, I will introduce the eye-tracking methodology used across the studies conducted for the present thesis, describe the studies and their results in more detail, and draw conclusions based on the results.

## 1.1. Theories on Irony Comprehension

Several theories explaining verbal irony comprehension, and figurative language comprehension in general, have been developed within the past five decades by researchers in different fields, including philosophy, linguistics, and psychology (e.g., *pretense theory*, Clark & Gerrig, 1984; *relevance theory*, Sperber & Wilson, 1995; and *implicit display theory*, Utsumi, 2000; see also Gibbs & Colston, 2012, for a review). Next, I will go through the four most influential theories in

chronological order: the standard pragmatic view, the direct access view, the graded salience view, and the parallel constraint satisfaction framework.

### 1.1.1. The standard pragmatic view

*The standard pragmatic view* (Grice, 1975; Searle, 1979) is the most famous theoretical model of figurative language comprehension. The view argues that the maxims of conversation are adapted to the comprehension of verbal irony and other forms of figurative language. These maxims include the expectations that the speaker should be informative, truthful, relevant, and clear in what s/he utters. According to Grice (1975), verbal irony violates the expectation of the speaker being truthful, or *the maxim of quality*. However, later analyses of the nature of verbal irony have shown that it can break all the maxims of conversation (Kaufer, 1981). According to the standard pragmatic view, when an utterance breaks the maxims of conversation, the intended meaning of the utterance is achieved via a three-step process. First, the utterance is processed as literal. Second, a discrepancy between the expected literal meaning of the utterance and the context in which it is presented is detected. Third, an alternative, ironic meaning of the utterance is considered (Grice, 1975; Searle, 1979). Thus, according to this view, comprehension of verbal irony requires more complex processing than comprehension of literal language. As a result, the view predicts longer processing times for the same sentence presented in a context making it ironic rather than literal.

The standard pragmatic view has received experimental support (e.g., Filik & Moxey, 2010). For example, several recent eye-tracking studies examining the processing of ironic vs. literal utterances embedded in a story context have shown longer total reading times for ironic utterances than for literal ones (Au-Yeung, Kaakinen, Liversedge, & Benson, 2015; Filik, Leuthold, Wallington, & Page, 2014; Filik & Moxey, 2010). As predicted by the standard pragmatic view, the results show that resolving irony causes problems in integrating the utterance with the developing text representation, causing a reanalysis of the utterance.

A major problem of the standard pragmatic view, at least from the perspective of this thesis, is that it does not take into account individual differences. However, this is understandable from the historical point of view, as the original purpose of the model was to give a general philosophical account of how the intended ironic meaning, and figurative meaning in general, of an utterance is derived (Bach, 2006).

### 1.1.2. The direct access view

In the late 1970s, psychologists started to test the processing of figurative language experimentally (e.g., Ortony, Schallert, Reynolds, & Antos, 1978). Some studies

suggested that the comprehension of ironic and metaphorical utterances would not necessarily take any longer, or could be comprehended even faster, than their literal counterparts, when presented in an adequate context (Gibbs, 1986; Ortony et al., 1978). These findings contrasted with the predictions made by the standard pragmatic view (Grice, 1975). Consequently, *the direct access view* was suggested as an alternative (see e.g., Gibbs, 1994a). The direct access view (Gibbs, 1994a) posits that verbal irony comprehension and production do not require special cognitive processes when compared to the comprehension of literal language. If the context in which a statement is presented supports an ironic interpretation, the intended meaning of an utterance may be comprehended as easily as the meaning of a literal utterance (Gibbs, 1994a). Thus, the processing time of an utterance presented in a context biasing towards an ironic interpretation is not necessarily any longer than the processing time of the same utterance in a literal context. However, when the context does not support direct access to the ironic meaning, readers should have difficulty in integrating the ironic utterance with the context, resulting in longer reading times for ironic utterances in comparison to times for literal ones (Gibbs & Colston, 2012).

In support of the direct access view, Gibbs (1986) reported that sarcastic statements were faster to read than their literal counterparts. Only when the sarcasm was positive, were sentences slower to process than their literal counterparts. However, the study has been criticized for comparing the processing times of different utterances (Giora, 1995). For example, the statement "You are such a good friend," uttered when a friend had treated somebody unfairly, was compared to "You are a terrible friend" as its literal counterpart: thus, there was a potential of confounding the processing difficulty of the target statements used (Giora, 1995).

As for the individual differences, according to Gibbs and Colston (2012), various readers and text-related factors may influence the ease of comprehending verbal irony. For example, a reader's working memory capacity (WMC) may play a role in how well irrelevant properties of an utterance, such as literal interpretation, are suppressed. Readers with a low WMC may thus have problems in inferring the intended ironic meaning. Moreover, the ability to infer the thoughts and emotions of another person (theory of mind) may also play a crucial role in how well a reader is capable of interpreting an utterance as ironic (Colston & Gibbs, 2002). When the reader is better able to recognize the intention behind an ironic comment, s/he does not necessarily need to engage in the additional processing that is sometimes required for the processing of verbal irony (Colston & Gibbs, 2002).

## 1.1.3. The graded salience view

Taking the direct access view further, *the graded salience view* proposed by Giora (1997, 2003) states that two distinct mechanisms affect the processing of verbal irony: salience of an utterance, and contextual information. The salience of an utterance is crucial for how quickly its meaning is accessed. According to this view, the most salient meaning of an utterance is available automatically regardless of the context. Salient ironic utterances are coded in the mental lexicon and should be highly accessible, for example, due to their familiarity (Giora, 2003). Typically, the literal meaning is salient, and it is accessed first. If the literal meaning does not fit into the context, an alternative interpretation is sought, resulting in longer processing times for ironic utterances in comparison to the times for literal ones (e.g., Bohrn et al., 2012; Giora & Fein, 1999). However, sometimes the ironic meaning is the most salient meaning, as with familiar ironies such as "big deal!" and "tell me about it!" (Giora, 2003), and the ironic meaning is accessed first. Consequently, the literal interpretation is not necessarily processed at all. According to the graded salience view, familiar ironies should thus be processed as quickly as, or even faster than, their literal counterparts (Giora, 1997, 2003). Context also plays a role: Contextual information can increase the predictability of irony and thus facilitate the comprehension of ironic utterances (Giora, 2003). Moreover, it should be noted that graded salience view has been superseded by *the defaultness hypothesis*. It differs from the graded salience view by introducing predictions of superiority of default non-literal interpretations, i.e. superiority of default sarcastic criticism over non-default positive sarcasm (Giora, Givoni, & Fein, 2015; see also Giora & Filik, 2018).

The graded salience view has received experimental support (Filik et al., 2014; Giora & Fein 1999). For example, Giora and Fein (1999) used the probe reaction time paradigm to study the activation of literal and ironic interpretation after reading a target sentence embedded in a story context. The target sentences included either familiar or unfamiliar ironies. They found that the salient (familiar) meaning was always activated first, supporting the notion that salient meanings are activated automatically. As for the processing times, Filik and colleagues (2014) studied the processing of ironic and literal utterances embedded in a story context using eye-tracking. They found no difference in reading times between familiar ironies and their non-ironic counterparts, whereas reading times for unfamiliar ironic utterances were longer in comparison to those for their non-ironic counterparts (Filik et al., 2014).

As for individual differences, the ability to inhibit or suppress the context-irrelevant meaning of an utterance may be related to verbal irony comprehension (Giora, 1999). For example, readers who have a low WMC may have difficulties in suppressing the salient literal meaning when the non-salient ironic meaning is intended, and consequently, have trouble constructing an ironic interpretation.

## 1.1.4. The parallel constraint satisfaction framework

Theories presented above have been criticized for explaining only a piece of the puzzle of verbal irony comprehension (see e.g., Gibbs & Colston, 2012; Pexman, 2008). A recent theoretical view, *the parallel constraint satisfaction framework*, tries to bring the different views together (Pexman, 2008). The framework states that readers make use of various linguistic (e.g., contextual information and familiarity) and non-linguistic cues (e.g., tone of voice, reader-related factors) to resolve the meaning of an utterance (Pexman, 2008; see also Katz, 2005; Katz & Ferretti, 2001). These cues are activated by the ironic utterance and are considered in parallel (Pexman, 2008). If the activated cues support an ironic interpretation, the other interpretation options (often literal) become inhibited. Moreover, if there are cues about forthcoming irony, the ironic utterance is comprehended more quickly than if there are no cues about the possible use of irony. Similarly, if the cues strongly support a literal meaning, a literal utterance is comprehended more quickly than an ironic utterance. The framework assumes that reader-related factors, such as how much a person uses irony (Ivanko et al., 2004), influence the processing of ironic statements by shaping the likelihood that different interpretations are active in the reader's mind.

The constraint satisfaction framework has received experimental support (Ivanko et al., 2004; Katz & Pexman, 1997; Pexman & Olineck, 2002). For example, it has been shown that if the person uttering the ironic comment belongs to a profession that is expected to be ironic (e.g., comedians), the profession works as a cue about ironic intent (Katz & Pexman, 1997; Pexman & Olineck, 2002). Ivanko and colleagues (2004) showed that a person's own likelihood for using sarcastic irony speeded up the processing of sarcastic utterances.

The problem with the parallel constraint satisfaction framework is that it does not specify the exact processes that are required for comprehending an ironic utterance; rather, it serves as a framework for understanding how individuals interact with multiple cues to resolve the ironic meaning of an utterance.

## 1.2. Individual Differences in Processing Irony

Previous research has suggested that the processing of verbal irony is more cognitively demanding than the processing of literal language (see e.g., McDonald, 1999). It is thought that individuals' own cognitive capacity serves as a constraint on their ability to comprehend and process (linguistic) information (e.g., *the capacity theory of comprehension*; Just & Carpenter, 1992). As a cognitively more demanding form of language, irony should create more demands on the readers' cognitive system. Hence, individual differences in verbal irony comprehension should be expected.

Most of the studies that have found individual differences have studied children (e.g., Nicholson, Whalen, & Pexman, 2013) or clinical populations (e.g., McDonald, 1999). However, some recent studies have shown that there are also individual differences among the healthy adult population (Ivanko et al., 2004). These differences have been shown to be related to an individual's own use of verbal irony (e.g., Ivanko et al., 2004). Higher self-evaluated use of ironic language is related to faster processing of ironic sentences.

The main objective of the present thesis is to study how individual differences in the different cognitive and emotional abilities[3], namely WMC and the ability to process emotional information, affect the processing of verbal irony among the healthy adult population.

## 1.2.1. Working memory capacity

Working memory can be defined as a system, or systems, of stores for temporarily maintaining information and as a supervisory or executive attentional mechanism (Baddley, 2010, Daneman & Carpenter, 1980; Engle, 2010; Just & Carpenter, 1992). In other words, working memory is not only a passive storage system, a short-term memory store, but also a system responsible for coordinating information processing (e.g., Baddley & Hitch, 1974). There are individual differences in the capacities of working memory (e.g., Daneman & Carpenter, 1980), and it is relatively widely accepted that these differences are related to the ability to control attentional resources so that relevant information is quickly activated and irrelevant information is inhibited (e.g., Engle, 2010, see also Gernsbacher, 1993). For irony comprehension, the reader would need to inhibit, for example, contextual information that is irrelevant to the interpretation. It has also been suggested that readers with a low WMC would have problems with inhibiting the salient (typically literal) meaning (Giora, 1999; see also Miyake, Just, & Carpenter, 1994). Consequently, difficulties with inhibiting the literal meaning would cause difficulties with integrating the ironic interpretation of the utterance with the context.

Only a few clinical studies tap into the relation between WMC and the processing of verbal irony (e.g., Martin & McDonald, 2005; Monetta, Grindrod, & Pell, 2009). These studies have failed to show a direct relation between working memory and irony comprehension. For example, Martin and McDonald (2005) studied factors behind deficits in irony comprehension among traumatic brain injury patients, and they failed to show a correlation between working memory and irony comprehension. They suggest that the failure to find a correlation may be related to the working-memory task of their choice, rather than a non-existent correlation

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[3]     It should be noted that cognitive and emotional functions are not necessarily separate from each other (see e.g., Pessoa, 2008).

between working memory and irony comprehension. They used the digit span task that measures only the storage component of working memory and does not tap into the inhibition component as the complex span tasks do (i.e., reading span task; Daneman & Carpenter, 1980). Monetta and colleagues (2005) studied verbal irony comprehension among Parkinson's patients. They did not find a correlation between working memory and irony comprehension either; however, they did find a correlation between working memory and an ability to attribute the mental states of others. They argued that working memory might still play a role in irony comprehension because the ability to attribute the mental states of others, which is needed in pragmatic reasoning, depends crucially on the ability to manipulate information in the working memory. Thus, the relation between working memory and irony comprehension might be indirect.

Although current clinical studies do not lend support to the notion that WMC would play a role in irony comprehension, it is noteworthy that 1) clinical findings might not provide a reliable picture of how working memory affects the processing of irony in the healthy adult population, and 2) the measures used have not been optimal to tap into the individual differences in WMC (Martin & McDonald, 2005). As the research literature shows, WMC plays a prominent role in reading comprehension (e.g., Daneman & Carpenter, 1980; Just & Carpenter, 1992), and there are well-reasoned theoretical suggestions that working memory would play a role also in irony comprehension (Giora, 1999). Hence, the present thesis explores the role of WMC in written irony comprehension.

Furthermore, there is an ongoing theoretical debate on whether the individual differences in WMC are domain-specific or domain-general (see e.g., Baddley, 2010; Daneman & Carpenter, 1980; Fougnie, Zughi, Godwin, & Marois, 2015; Kane et al., 2004; Oswald, McAbee, Redick, & Hambrick, 2014). The domain-specific view posits that a specific working memory task is related to outcomes relevant to that specific ability. For example, a reading-related working memory task, such as the reading span task, for which you need to recall the final words of sentences (Daneman & Carpenter, 1980), is related to linguistic abilities. In contrast, the domain-general view posits that task requirements are common across working memory tasks, and all working memory tasks reflect attentional control (e.g., Kane et al., 2004).

In the present thesis, the reading span task (Daneman & Carpenter, 1980) is primarily used because both views would assume it to be related to the processing of written irony. However, it is also possible that the visuospatial working memory might have a role in the processing of written irony. Obviously, the domain-general view assumes that the symmetry span task (Redick et al., 2012) used to measure visuospatial working memory would capture the same variance as the reading span

task, and the high scores would indicate a better overall ability to allocate attentional resources.

Previous studies show that readers build a spatial representation of the text while reading (see e.g., Baccino & Pynte, 1994; 1998; Kennedy, Brooks, Flynn, & Prophet, 2003; Murray & Kennedy, 1988). The spatial representation allows readers to carry out selective re-inspections of the text, which is more efficient than just reading the whole text again (Kennedy et al., 2003). Re-inspections made during the course of reading, or regressive eye movements, have been shown to be related to resolving ambiguities in a text (e.g., Frazier & Rayner, 1982; Meseguer, Carreiras, & Clifton, 2002; Mitchell, Shen, Green, & Hodgson, 2008) and to reading comprehension (e.g., Booth & Weger, 2013; Hyönä, Lorch, & Kaakinen, 2002; Hyönä & Nurminen, 2006; Rayner, Chace, Slattery, & Ashby, 2006; Schotter, Tran, & Rayner, 2014; White, Lantz, & Paterson, 2016). It has been suggested that returns to text during the course of reading do not necessarily indicate a need to re-examine the information itself, but a need to focus attention on what had appeared there (Meseguer et al., 2002). Moreover, it has been shown that the re-activation of a memory representation sometimes drives the eyes to an already-viewed location, and this enhances subsequent memory retrieval (Ferreira, Apel, & Henderson, 2008). According to some theories of irony comprehension, an ironic utterance is first processed as literal (at least under specific circumstances), and after the discrepancy between the literal and intended meaning is detected, a new meaning is determined for the utterance (e.g., Grice, 1975). This process presumably requires re-processing of the ironic statement and the text context, and some recent eye-tracking findings suggest that this might indeed be the case (e.g., Filik & Moxey, 2010). It is possible that visuospatial working memory might play a role in regressive eye movements that occur when attaching the new meaning to the statement. Thus, it is possible also from the domain-specific point of view that, at least to some extent, the visuospatial working memory might also play a role in reading comprehension, and it would be specifically related to the reprocessing of ironic statements.

## 1.2.2. The ability to process emotional information

Verbal irony serves a social function that is not achieved by speaking directly, so it conveys an emotional message that differs from the meaning of the literal interpretation (see e.g., Akimoto et al., 2014). For example, an ironic speaker typically intends to convey a negative attitude, especially while using sarcastic irony, and thus, ironic comments might be perceived as insulting (Akimoto et al, 2014; Bowes & Katz, 2011; Gibbs & Izett, 2005; Leggitt & Gibbs, 2000; Winner & Leekam, 1991). Irony might also be used as a form of humor, and thus, ironic statements may be perceived as funny (Akimoto et al, 2014; Dews et al, 1995;

Jorgensen, 1996; Kreuz, Long, & Church, 1991). The parallel constraint satisfaction framework suggests that inferring the intended emotional message delivered by the ironic statement works as a supporting cue for ironic interpretation, which should make processing of the ironic meaning easier or faster (Pexman, 2008). This suggestion is in line with more general findings showing that emotional content facilitates word processing, resulting in faster processing times in comparison to the processing of neutral words (see e.g., Kaakinen et al., 2018, for a review).

Recent studies have shown that emotional processing is related to irony comprehension (Amenta et al., 2013; Jacob, Kreifelts, Nizielski, Schütz, & Wildgruber, 2016; Nicholson et al., 2013; Shamay-Tsoory et al., 2005; Shany-Ur et al., 2012). Jacob and colleagues (2016) used short videos to examine whether a mismatch between verbal and nonverbal information is perceived as irony, and whether emotional intelligence is related to how easily incongruent materials are categorized as ironic. Their results showed that incongruence between verbal and nonverbal cues was indeed related to the impression of irony, and participants scoring high in the emotional intelligence questionnaire were faster in categorizing slightly incongruent materials as ironic in comparison to those scoring low in emotional intelligence. Moreover, previous clinical studies and studies on children have demonstrated that the ability to process emotional information plays a seminal role in irony comprehension (Amenta et al., 2013; Nicholson et al., 2013; Shamay-Tsoory et al., 2005; Shany-Ur et al., 2012). For example, Shany-Ur and colleagues (2012) showed that patients with neurodegenerative diseases failed at complex social-cognitive tasks, such as emotion reading, leading them to misinterpret sarcastic irony. Moreover, the presence of good empathy skills in children has been shown to be related to better judgment of a speaker's intent as well as better comprehension of irony (Nicholson et al., 2013).

However, the questions of whether the ability to process emotional information affects the processing of written irony or of irony comprehension among the healthy adult population still remains unanswered. Consequently, these questions were explored in the present thesis.

In previous studies, a variety of tasks and methodologies has been used to study emotion processing abilities and their relation to experiencing, processing, or comprehending verbal irony. In the present thesis, two different tasks were used to measure individual differences related to the ability to process emotional information: Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994) and 20-item Toronto Alexithymia Scale (TAS; Bagby, Parker, & Taylor, 1994; Joukamaa et al., 2001). The selection of tasks was influenced by their relevance to irony comprehension and by being able to reliably use them in Finnish, the language studied in the present thesis.

IGT is thought to measure an individual's sensitivity to emotional responses to reward and/or punishment in a decision-making task, and this emotional response is thought to be, at least to some extent, unconscious (e.g., Buelow & Suhr, 2009). It is developed as a neuropsychological tool to detect patients with lesions on the ventromedial prefrontal cortex, who have deficits in employing emotional information in decision-making. Ventromedial lesions have been shown to be related to deficits in sarcasm comprehension (Shamay-Tsoory et al., 2005). Moreover, prefrontal areas in general have been shown to be active during irony comprehension (e.g., Akimoto et al., 2014; Uchiyama et al., 2006). IGT is sensitive enough to also capture variance among a healthy population (e.g., Suhr & Tsanadis, 2007). Thus, IGT should capture emotional responses relevant to irony comprehension, and it should be related to the immediate emotional response evoked after the reader has processed an ironic statement and starts to build an inference.

TAS, on the other hand, measures individuals' ability to recognize and name emotions (i.e., alexithymic traits). In contrast to IGT, TAS should reflect a more conscious emotional processing ability. In terms of verbal irony comprehension, TAS should be related to readers' ability to name and recognize the protagonist's intention to insult another person, and this should help in inferring the meaning of the statement. TAS has been used before, at least in one clinical study, to explore relation between alexithymic traits and irony comprehension (Dimaggio et al., 2011). In their study, Dimaggio and colleagues (2011) explored among psychiatric patients the relationship between alexithymic traits (as measured with TAS) and comprehension of ironic jokes in cartoons. Their results showed that an increase in alexithymic traits was related to slower categorization of jokes as ironic. Moreover, TAS has also been shown to be sensitive enough to capture variance in the ability to recognize and name emotions among a healthy population (e.g., Luminent, Vermeulen, Demaret, Taylor, & Bagby, 2006), which is why it is used in the present study.

## 1.3.  Verbal Irony and Metaphors

Metaphor can be defined as "a figure of speech comparing two unlike things without using 'like' or 'as'" (*Merriam-Webster Dictionary*, 2017). Most of the metaphors appear in the form A is B (Gibbs, 1994b); for example, *marriage is a roller coaster ride*. A metaphor is constructed from its parts A and B, which are referred to as *topic* and *vehicle*, respectively (Glucksberg, 2001). To comprehend the metaphor in the example, you need to know what qualities marriages (topic) and roller coaster rides (vehicle) carry and what qualities of the vehicle are relevant from the topic's perspective (Glucksberg, 2001); for example, that both contain ups and downs.

Traditionally, it was thought that for different forms of figurative language, such as irony and metaphors, the intended meaning would be achieved via a similar process (Grice, 1975). Irony and metaphors break the same rule of communication, the *maxim of quality*, or the expectation of the speaker being truthful (Grice, 1975). In contrast to this traditional view, for the following reasons, it has been suggested that irony and metaphors should be different in respect of their structure, function, and comprehension demands (Winner & Gardner, 1993). First, metaphors express similarities between the topic and the vehicle, whereas irony creates a contrast between what is said and what is implied. Second, irony delivers the speaker's opinion about the topic, whereas metaphors describe the topic. Third, metaphors and irony pose different cognitive demands: To comprehend a metaphor, a reader should have sufficient prior knowledge, for example, about marriages and rollercoasters. On the other hand, successful comprehension of irony requires that the reader is sensitive to the emotional state of the speaker and can infer the meaning from what is actually being said (Akimoto et al., 2014).

Previous research has given support to the notion that metaphors and irony are indeed processed differently (Colston & Gibbs, 2002; Pexman, Ferretti, & Katz, 2000). Ironic sentences have been shown to be slower to read than metaphorical sentences (Colston & Gibbs, 2002). Moreover, metaphorical ironies have been shown to be slower to read than ironic sentences (Colston & Gibbs, 2002) and metaphors (Pexman et al., 2000). Brain imaging studies also support these findings by showing that irony and metaphors activate different areas in the brain (Bohrn et al., 2012; Rapp et al., 2012).

One of the aims of the present thesis was to examine whether the processing of verbal irony differs from that of the other forms of figurative language, namely metaphors, in contrast to the traditional view (Grice, 1975). Moreover, the purpose of the present thesis was to examine to what extent individual differences in the processing of irony and metaphors arise from specific cognitive demands related to the type of figurative language, as suggested by the former research literature (e.g., Colston & Gibbs, 2002; Winner & Gardner, 1993).

## 1.4. Eye-Tracking Methodology

Most of the studies on the processing of written irony have used the probe reaction time methodology (e.g., Giora, Fein, & Schwartz, 1998) or the moving window paradigm, in which readers are shown the text one word at a time (e.g., Ivanko et al., 2000; Pexman et al., 2000). These methodologies allow for only one processing time measurement (e.g., first-pass reading time for each word in an ironic utterance), without the possibility of examining for variation in the processing (e.g., rereading

of the ironic statement). These methodologies also disturb normal reading (see e.g., Rayner 1998 for review).

Eye-tracking was used across all four studies on which this thesis is based. Using eye-tracking methodology, it is possible to tap into the moment-to-moment cognitive processing during reading (Rayner, 1998; 2009). Thus, it is an excellent method for resolving the detailed time-course for processing written language, and, especially relevant to this thesis, for the processing of written irony. Eye-tracking is a relatively unobtrusive method that allows normal reading, and it gives moment-to-moment data for the progress of reading. The present dissertation project is one of the first to use eye-tracking to study the processing of verbal irony (the first study being that of Filik & Moxey, 2010). However, during the course of this project, several new studies using eye-tracking methodology emerged (e.g., Au-Yeung et al., 2015; Filik, Brightman, Gathercole, & Leuthold, 2017; Filik et al., 2014; Filik & Moxey, 2010; Turcan & Filik, 2016). These served to prove the usefulness of the methodology in studying the processing of ironic language.

Eye-tracking has been used to study reading for decades. Technical development of eye-tracking systems has progressed relatively quickly since the mid-1970s, resulting in an extensive amount of literature on cognitive processes underlying reading as reflected in eye-movements (Rayner, 1998; 2009). Most of the studies thus far have been focused on the processing of single words and how the qualities of a word (such as word frequency) and its meaning in the sentence (e.g., whether or not it is ambiguous) affect the processing times. Within the last decade or so, an increasing number of experiments have been concentrating on global text processing (i.e., the processing of texts longer than one or two sentences; see e.g., Jarodzka & Brand-Gruwel, 2017). These sentence-level analyses are particularly informative when the "area of interest" is not a single word (cf. Rayner, 1998), but consists of a phrase or a sentence (Hyönä, Lorch, & Rinck, 2003), which is often the case with ironic statements. This approach was deemed more suitable for studying the processing of verbal irony because a single word can rarely be counted as ironic and thus is a sentence-level phenomenon. Consequently, across all four studies for this thesis, sentence-level measures were computed from the eye-movement data (see Hyönä et al., 2003). However, in Study III, some of the measures used were different from those used in the other studies of this thesis. The measures used across the experiments are presented in Table 1.

Eye fixations can be categorized into fixations done during the *first-pass reading* of a sentence and to later *look-backs* that are initiated from subsequent parts of text. First-pass sentence reading can be further divided into *forward-fixations* that land on unread parts of the sentence, and to *first-pass rereadings*, which are fixations that return to earlier parts of the sentence (Liversedge, Paterson, & Pickering, 1998). If effects are found in first-pass reading, the effect is thought to reflect immediate

difficulty in processing that text region (Liversedge et al., 1998). Forward-fixation time consists of gaze durations on consecutive words that were read in a progressive manner, thus reflecting the efficiency of word recognition in sentence context (Rayner, 1998; 2009). On the other hand, first-pass rereading is thought to reflect comprehension difficulty (Hyönä et al., 2003; Liversedge et al., 1998). *Regression-path duration* is typically reported in studies examining processing of specific target words embedded in a sentence, and it is thought to reflect difficulty in processing the critical text region (Liversedge et al., 1998).

Table 1

*Descriptions of the Eye Movement Measures Used Across the Studies of this Thesis*

| Measure | Description | Studies used in |
|---|---|---|
| First-pass reading time | Summed duration of fixations made on one sentence before moving to the next. | I, II, III, IV |
| Forward-fixation time | Summed duration of fixations that land on unread parts of the sentence during first-pass reading. | I, II, IV |
| First-pass rereading time | Summed duration of fixations that were made during the re-inspection of the sentence before moving to the next. | I, II, IV |
| Regression path duration | Summed duration of the fixations that occurred from the first fixation in a sentence until the participant moved his/her eyes beyond the sentence to the right. | III |
| Look-back fixation time | Summed duration of fixations returning to the sentence from other parts of the text after the first-pass reading. | I, II, III, IV |
| Look-from fixation time | Summed duration of look-back fixations that were initiated from the sentence. | I, II, IV |

Look-back measures, *look-back fixation time* and *look-from fixation time*, are thought to reflect a conscious effort (Hyönä & Nurminen, 2006) to build a comprehensive mental representation of the text contents (Hyönä et al., 2002). Readers are able, at least to some extent, to report after reading whether they looked back in the text, and if they did, where (Hyönä & Nurminen, 2006). Moreover, readers who initiate look-backs to important parts of the text gain better comprehension than readers who look back more randomly (e.g., Hyönä et al., 2002).

## 1.5. Aims and Hypotheses

The aim of the present thesis was to answer the following questions: 1) How do readers resolve the meaning of irony? 2) How do individual differences in WMC and the ability to process emotional information affect the processing of irony? and 3) Does the processing of irony differ from the processing of other forms of figurative language, namely metaphors? These questions were examined across four studies using eye-tracking to tap into the detailed time-course of resolving the meaning of irony.

Four hypotheses emerged from the previous research literature:

1) Written ironic statements should take more time to process when the ironic utterance itself is not familiar and when there are no advanced cues for forthcoming irony.

2) WMC relates to a better ability to inhibit irrelevant and more salient literal meaning; thus, high WMC readers should show faster/earlier processing of ironic utterances.

3) Emotional components in the processing of irony should serve as cues pointing towards ironic interpretation and should facilitate the processing of verbal irony. Thus, those who have a better ability to process emotional information should show faster processing of ironic meaning.

4) Ironic statements should be harder to process than metaphorical statements, resulting in faster/earlier processing of metaphorical statements than the processing of ironic ones. Moreover, individual differences in general cognitive factors, such as WMC, should be related to the processing of both metaphors and irony, whereas the efficiency of emotional processing should be specific to the processing of irony.

# 2.Overview of the Studies

## Study I

Kaakinen, J. K., Olkoniemi, H., Kinnari, T., & Hyönä, J. (2014). Processing of written irony: An eye movement study. *Discourse Processes, 51*, 287–311.

Study I consisted of two experiments. Experiment 1 explored the processing of verbal irony, while Experiment 2 explored individual differences in the processing of verbal irony related to WMC, self-reported use of sarcasm, and cognitive style. Across the experiments, participants read target utterances embedded either in an ironic or non-ironic story context while their eye movements were recorded (Exp. 1, $N = 52$, Exp. 2, $N = 60$). Some of the texts were translated and modified versions of the texts used by Weingartner and Klin (2005), and other experimental and filler texts were written for the purpose of this study (24 experimental texts and 6 fillers). The texts were slightly modified for Experiment 2 so that all the ironic utterances contained sarcastic irony, and the number of filler items was increased (24 experimental texts, and 12 fillers). An example text is presented in Table 2. After reading each story, participants responded to a text memory question and an inference question that tapped into the understanding of the meaning of the target utterance. The percentage of correct answers was calculated for both text memory and inference questions.

In Experiment 2, individual differences related to WMC were measured using the reading span task (Daneman & Carpenter, 1980), usage of sarcastic language was measured using the Sarcasm Self-Report Scale (SSS; Ivanko et al., 2004), and cognitive style was measured using the Need for Cognition Scale (NFC; Caccioppo, Petty, & Kao, 1984).

The results of Experiment 1 showed that readers were more likely to reread ironic than non-ironic target sentences during the first-pass reading as well as during later look-backs. Moreover, readers were poorer at answering inference questions concerning ironic rather than literal target utterances.

The results of Experiment 2 showed that WMC, but not SSS or NFC, played a role in how readers resolved the meaning of ironic sentences. High WMC was related to the increased probability of initiating first-pass rereading of ironic sentences compared to the rereading of literal sentences. Moreover, readers were poorer at answering inference questions concerning ironic utterances than they were at answering those concerning literal target utterances, thus replicating the findings of Experiment 1.

Table 2

*Example of an Experimental Text Used in Study I*

| Text Segment | Text Type | Text |
|---|---|---|
| Pre-context | | An old action movie sequel was recently released in the movie theaters. Eemil was really excited about this because he had really loved the original movie. He asked his friend Ville to join him in watching the movie. "It's going to be the best movie ever," Eemil praised the movie to Ville. Ville agreed, and they met in the evening at the movie theater. |
| Critical context | Literal | The movie was a great sequel to the original movie. New special effects made the film really impressive. |
| | Sarcastic | The movie was a dull copy of the original. Even the jokes were the same. |
| Target phrase | | "That was definitely the best movie ever." |
| Spillover region | | Ville said after the movie, grinning. |
| Paragraph end | | The boys decided to have something to eat before going home. |
| Text memory question | | Were Eemil and Ville at a concert? |
| Inference question | | Did the boys like the movie? |

Note: Example given is a translation from Finnish.

The results suggest that the processing of irony requires extra effort and that the effects are localized in the ironic sentence. The result is in line with those theories that assume that the processing of an ironic phrase that is not familiar and is not supported by the story context should be slower than its literal counterpart (Gibbs, 1994a; Giora, 2003; Grice, 1975; Pexman, 2008), as was the case in this experiment.

However, the results showed that despite the extra processing effort, readers were not always able to resolve the meaning of irony. Moreover, the results suggest that a high WMC facilitates the recognition of an utterance as ironic by helping the reader to either maintain or activate alternative interpretations for the utterance. To conclude, the results showed that there are individual differences in the processing of verbal irony related to WMC. These findings confirm that a reader's cognitive abilities matter in the processing of ironic utterance.

# Study II

Olkoniemi, H., Ranta, H., & Kaakinen, J. K. (2016). Individual differences in the processing of written sarcasm and metaphor: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*, 433–450.

In Study 2, differences between the processing of two forms of figurative language, sarcastic irony and metaphor, were examined. Previous research literature has suggested that the comprehension of sarcastic irony and metaphor create different cognitive demands for the reader (Colston & Gibbs, 2002; Pexman et al., 2000). Specifically, it has been suggested that comprehending metaphors requires knowledge about the qualities of both the topic and the vehicle, and an ability to connect the two. On the other hand, successful comprehension of sarcasm requires the reader to be sensitive to the emotional state of the speaker and to able to infer the intended meaning of the statement (Akimoto et al., 2014). Thus, different reader-related characteristics should be related to the processing of metaphors and sarcasm. It was expected that individual differences in general cognitive factors, such as working memory and cognitive processing styles, would be related to the processing of both types of figurative language, whereas individual differences in the efficiency of emotional processing would be specific to the processing of sarcasm. Thus, Study II explored whether the processing of sarcastic irony and metaphors relies on general cognitive constraints (WMC and NFC) or whether it poses specific cognitive demands.

In the study, 60 participants read ironic, metaphorical, and literal sentences embedded in story contexts (each participant read a total of 30 stories) while their eye movements were recorded, and they responded to a text memory and an inference question after each story. The percentage of correct answers was calculated for both text memory and inference questions. An example story is presented in Table 3. Experimental stories were pre-tested for the familiarity of the utterances as literal, metaphoric, and ironic in meaning; how natural each type of utterance was in the story context; whether the emotional state of the speaker was apparent in the

ironic statement; and whether the context supported a figurative interpretation. All figurative utterances were rated as unfamiliar; literal, metaphoric, and ironic target utterances were evaluated to be natural in the story context; ironic utterances were evaluated to be less positive and more negative than their metaphoric and literal counterparts; and the story contexts did not provide cues about figurative interpretation for the utterance.

Individual differences in WMC were measured using the reading span task (Daneman & Carpenter, 1980), the cognitive style of the reader was measured using the NFC (Cacioppo et al., 1984), and the ability to process emotions was measured using the IGT (Bechara et al., 1994).

The results revealed differences in the processing patterns for irony and metaphors, as well as individual differences in how readers processed these types of figurative language. The processing of metaphors was characterized by a slowdown during the first-pass reading of the utterances, suggesting that readers are sensitive to the metaphors and are able to start processing the meaning of them on the spot. Moreover, the results showed that there are individual differences related to general cognitive factors (WMC and NFC) in the processing of metaphors. Readers with low WMC tended to look back to metaphorical sentences and seemed to need extra time to process metaphors. It might be that low WMC readers may have trouble in suppressing salient literal meaning and thus need to look back to the metaphorical target sentence in order to refresh it in working memory so that the metaphorical interpretation can be validated (see e.g., Giora, 1999).

A higher NFC score was related to more time spent on rereading metaphors. To comprehend the meaning of a metaphor, the reader needs to retrieve conceptual information from his/her world knowledge (see e.g., Glucksberg, 2001). It has been shown that high NFC individuals are motivated to carry out tasks that require reasoning (Cacioppo, Petty, Feinstein, & Jarvis, 1996). One possible explanation is that metaphor processing offers high NFC readers a challenge that draws their attention towards the metaphorical utterance. The ability to process emotional information was not related to the processing of metaphors.

The processing of irony was characterized by the increased probability of first-pass rereading and of looking back at the text. Ironic utterances were also harder to comprehend than literal or metaphorical utterances, as indicated by a poorer performance in inference questions; this replicated the findings of Study I. These findings imply that the processing of irony is characterized by extra integrative processing and rechecking the context in search of an alternative meaning. Despite this extra processing effort, readers do not always understand the intended ironic meaning of the utterance.

Table 3
*An Example of Experimental Text Used in Study II*

| Text region | Text type | | |
| --- | --- | --- | --- |
| | *Literal* | *Sarcasm* | *Metaphor* |
| Introduction | Paul and Zachary work at a circus. Tonight's show is sold out. | Paul and Zachary work at a circus. Tonight's show is sold out. | Paul and Zachary are students at the same school. Their teacher leaves the classroom to make photocopies. |
| Critical context | When Paul is on stage, the audience laughs loudly. When Paul leaves the stage, he gets a standing ovation. | When Paul is on stage, the audience looks bored and some people yawn. When Paul leaves the stage, he gets a small round of applause. | Paul goes in front of the class and starts to imitate the teacher. The whole class laughs aloud at Paul's show. |
| Target sentence | "What a clown you are!" | "What a clown you are!" | "What a clown you are!" |
| Spillover region | Zachary shouts. | Zachary shouts. | Zachary shouts. |
| Paragraph end | Later Zachary asks Paul if he would like to go to the movies. | Later Zachary asks Paul if he would like to go to the movies. | Later, Zachary asks Paul if he would like to go to the movies. |
| Text memory question | Does Paul work at the circus as a clown? | Does Paul work at the circus as a clown? | Were Paul and Zachary in the city? |
| Inference question | Did Zachary think that Paul's show was a success? | Did Zachary think that Paul's show was a success? | Is Paul a professional circus clown? |

*Note*. Translated from Finnish. There were three different versions (literal, metaphoric, and sarcastic) of each text; each participant read only one of the versions. Text versions were counterbalanced across participants.

Individual differences in both general cognitive factors (WMC) as well as the processing of emotional information were related to the processing of irony. High WMC was related to an increased probability of rereading ironic sentences when compared to the rereading of literal ones towards the end of the experiment, whereas low WMC was related to an increased probability of look-back to the ironic (vs. literal) sentences; this replicated the findings of Study I. Poor ability to make use of emotional information (low IGT scores) was related to an increased probability of look-back from the ironic target sentences, whereas high IGT scores were related to a decrease in look-back at the parts of the context that made the utterance ironic. These findings indicate that the efficiency of making use of emotional information is related to the speed with which readers are capable of resolving the ironic meaning, and furthermore, poorer ability is related to more effortful processing of the ironic utterances. NFC was not related to the processing of irony; this replicated the results of Study I.

Some of the reading time effects related to the processing of both irony and metaphors changed during the experimental session, and these changes were modulated by the WMC. First, overall, the probability of initiating a look-back to a target utterance decreased towards the end of the experiment; however, low WMC readers did not show this change in the probability of look-back to metaphorical utterances. Second, high WMC was related to an increased probability of rereading ironic statements toward the end of the experiment. The result suggests that exposure to the figurative utterances during the course of the experiment formed a global context that supported the ironic interpretation and aided the interpretation formation.

The results of Study II suggest that different forms of figurative language create different cognitive demands for the reader. They also suggest that reader characteristics play a prominent role in figurative language comprehension.

# Study III

Olkoniemi, H., Strömberg, V., & Kaakinen, J. K. (2018). The ability to recognise emotions predicts the time-course of sarcasm processing: Evidence from eye movements. *Quarterly Journal of Experimental Psychology*. Advance online publication.

In verbal irony, there is a discrepancy between the literal meaning of the statement and the context in which it is presented. Consequently, an ironic statement introduces a break in the local coherence of the text. Previous studies have shown that written ironic statements in stories often elicit longer processing times than their literal counterparts (e.g., Au-Yeung et al., 2015, Filik & Moxey, 2010; Study I; Study II),

presumably reflecting the difficulty of integrating the statement with the context (e.g., Grice, 1975). The aim of Study III was to examine whether the observed slowdown in the reading of the ironic utterances was related specifically to resolving the meaning of irony or whether it merely reflected readers' efforts to resolve the local inconsistency (e.g., McKoon & Ratcliff, 1992). Moreover, it explored how individual differences in the ability to recognize emotions and WMC were related to this process.

In Study III, 60 participants read a total of 60 short paragraphs including sarcastic irony and literal statements (20 ironic, 20 literal, and 20 filler items) while their eye movements were recorded. In the paragraphs, the location of the local coherence break was manipulated by presenting the ironic dialogues either before (context-last condition) or after (context-first condition) contextual information. Text paragraphs included one or two context sentences and simple dialogues (two lines) between two people (see an example in Table 4). In the context-first condition, context sentences were presented before the dialogue, resembling previous eye-tracking studies (see e.g., Tables 2 and 3). In the context-first condition, irony became evident immediately when the reader encountered the target statement. Conversely, in the context-last condition, the target statement was presented first and irony became evident after the target statement, in the validation statements. It was assumed that if the effects observed in previous studies on the processing of verbal irony are related to local inconsistency, longer reading times should be observed for ironic rather than for literal validation statements in the context-last condition. However, if resolving the ironic meaning requires the reprocessing of the ironic statement, readers should make more look-backs to the ironic target statement in the context-last condition. Paragraphs used in the study were pre-tested for the following: 1) how familiar the target statements were as ironic when compared to those with a literal meaning ($N =$ 25); and 2) how ironic statements were experienced compared with literal statements ($N = 52$). The result of the pre-test showed that the target statements were overall more familiar as literal statements than as ironic, and ironic statements were rated as being funnier and more insulting when compared to literal ones. Moreover, the context manipulation had no effect on how the paragraphs were evaluated or comprehended.

After a third of the stories, participants responded to a text memory question (e.g., "Was Peter's car new?") and an inference question (e.g., "In your opinion, what did Veikko mean?") that tapped into the understanding of the meaning of the target utterance. The percentage of correct answers was calculated for both text memory and inference questions. Individual differences in WMC were measured using the reading span task (Daneman & Carpenter, 1980), and the ability to recognize emotions was measured using TAS (Bagby et al.,1994; Joukamaa et al., 2001).

Table 4

*Examples of Experimental Paragraphs used in Study III*

| Context | Region | Text type | Text |
|---|---|---|---|
| First | Context | *Literal* | Veikko takes a closer look at a new car that his friend Peter has bought. |
| | | *Sarcastic* | Veikko takes a closer look at a rusty car that his friend Peter has bought. |
| | Target statement | | Veikko: "The car looks great!" |
| | Validation statement | *Literal* | Peter: "Wait until you see how it drives." |
| | | *Sarcastic* | Peter: "Well, it's not in the best condition." |
| Last | Target statement | | Veikko: "The car looks great!" |
| | Validation statement | *Literal* | Peter: "Wait until you see how it drives." |
| | | *Sarcastic* | Peter: "Well, it's not in the best condition." |
| | Context | *Literal* | Veikko takes a closer look at a new car that his friend Peter has bought. |
| | | *Sarcastic* | Veikko takes a closer look at a rusty car that his friend Peter has bought. |

*Note*. Examples are translations from Finnish. There were two different versions of each paragraph (literal and sarcastic); each participant read only one of the versions, which were counterbalanced across participants.

The results showed that readers increased the reprocessing of the statement in which the irony became evident (target statement in the context-first condition and validation statement in the context-last condition) and returned to the previous text part from the statement. However, in the context-last condition, readers also did longer look-backs to ironic target utterances. The results suggest that the slowdown typically observed with ironic statements in a text is partly related to resolving a coherence break, but there also is a component related to resolving the ironic meaning. The result supports the idea that resolving the meaning of irony requires re-evaluating the meaning of the statement (e.g., Grice, 1975).

The results also suggest that forming a correct interpretation of the ironic statement is somewhat easier when the context is presented after it, at least for those who are poorer at recognizing emotions. In the context-first condition, readers who have a relatively poor ability to recognize emotions (i.e., higher scores on the TAS) showed increased first-pass reading time on the validation statements in the ironic paragraphs. These findings support the hypothesis that poor ability to recognize emotions is related to greater confusion when encountering ironic statements, which is in line with Study II of this thesis. The result suggests that the intended emotional message in irony serves as a cue that points toward the ironic interpretation, helping the reader to infer the intended meaning (Pexman, 2008). Those having difficulties noticing or interpreting the emotional message delivered by an ironic statement need more contextual information to form the correct inference. However, this effect was not seen in the context-last condition. It has been suggested that when the context is presented first, integrating the meaning of the ironic statement with the context is more difficult than when the statement precedes the context (Ackerman, 1982; cf. Grice, 1975). When the context precedes the sarcastic statement, readers have already started to build a literal text representation in their minds; thus, the reader expects a literal statement (e.g., Gibbs, 1994; Giora, 2003). This causes the extra processing in the context-first condition for ironic statements. However, when the context comes after the statement, there is no text representation that the statement should be integrated with, or at least it is not as strong as in the context first condition, and the reader is more open to different interpretations. The statement might be a literal or ironic comment, which would become evident only later, and there is less need for extra processing of the target statement. The results suggest that in the context-last condition, readers have not started to build a literal text representation before the statement, but rather have started to build an ironic interpretation as early as possible (Ackerman, 1982). This seems to especially aid readers who have a poorer ability to recognize emotions and, thus, may not be able to recognize the emotional cues; they may need to form an inference based on contextual cues provided in the text.

As for the individual differences related to WMC, Study III failed to replicate the findings of Studies I and II. The text materials used in Study III were very short in comparison to those used in the previous studies (3–4 sentences; in previous studies 5–14 sentences were used). It might be the case that shorter paragraphs do not strain working memory, which is likely to diminish the effects related to WMC.

Finally, it is also worth noting that Study III replicated some of the previous findings not directly related to the experimental manipulation. First, some of the effects related to the processing of irony changed during the experimental session, replicating the findings of Study II (see also Spotorno & Noveck, 2014). It is possible that ironic statements encountered during the experiment created a global context in

which irony was increasingly more likely to appear, affecting the processing of the paragraphs. Moreover, Study III replicated the findings of Studies I and II in showing that readers were poorer at responding to the inference questions after ironic paragraphs than they were at responding after literal paragraphs. However, in Study III, readers were more accurate when answering text-memory questions related to ironic texts than they were when answering after literal texts, suggesting that the extra effort invested in the processing of irony helps readers to better recall the text content.

# Study IV

The results of Studies I–III showed that when resolving the meaning of ironic utterances in a text, readers often make fixations that return to the ironic utterance from subsequent parts of the text (see also e.g., Au-Yeung et al., 2015, Filik et al., 2014; Filik & Moxey, 2010; Turcan & Filik, 2016). From the theoretical point of view, these look-backs may reflect that readers are trying to integrate the ironic statement with the developing text representation, which requires a reanalysis of the statement (e.g., Grice, 1975). The former studies suggested that the reason for re-inspections was that readers wanted to refresh the text information in their memory, which supports comprehension (e.g., Booth & Weger, 2013; Hyönä et al., 2002; Hyönä & Nurminen, 2006; Rayner et al., 2006; Schotter et al., 2014; White et al., 2016).

However, an interesting possibility is that look-back at a text does not necessarily indicate a need to re-inspect the information itself, but a need to focus attention on what had appeared in that location (Meseguer et al., 2002). Sometimes eye movements to already-viewed locations are triggered by the re-activation of a memory representation, and this enhances subsequent memory retrieval (Ferreira et al., 2008). This view is supported by studies showing that if a relevant visual stimulus was presented to a certain location on screen, people sometimes fixated on that location even after the stimulus was removed; they looked at nothing (see e.g., Ferreira et al., 2008 for review; see also Meseguer et al., 2002). Furthermore, it has been shown that if this looking at nothing behavior is restricted, by asking participants to maintain central fixation, it disrupts memory retrieval of the visual information (e.g., Laeng & Teodorescu, 2002). Therefore, look-backs may support the refreshing of text information in memory by either 1) focusing attention on a certain spatial location, which aids in retrieving the text contents from memory; and/or 2) by providing a review of the text content itself. In Study IV, the availability

of the text information during the later look-backs was manipulated to examine the role of these look-back fixations in the processing of sarcastic irony. Moreover, it explored whether there are individual differences related to WMC and the processing of emotional information in how readers resolve irony.

In the Study, 62 adult participants read a total of 42 short paragraphs containing either a literal or ironic utterance while their eye movements were recorded. The text paragraphs used were the same as in Study II. The texts were presented using a modified trailing mask paradigm utilized in previous sentence-reading studies (Schotter et al., 2014; see also McConkie & Rayner, 1975) to be suitable for passage reading. In the masking condition, readers revealed the text (that was initially replaced with x's) one sentence at a time by pressing the spacebar, and the previously read sentence was always replaced with x's as soon as the reader moved to the next sentence. This type of masking allowed readers to perform normal first-pass rereading of the sentence, but prevented re-examination of the text content during later look-backs. In the no-masking condition, readers revealed initially masked text one sentence at a time by pressing the spacebar, and the sentences remained visible throughout the trial. After reading each story, participants responded to a text memory and an inference question. The percentage of correct answers and response times were calculated for both text memory and inference questions.

Individual differences in WMC were measured using the reading span task (verbal working memory; Daneman & Carpenter, 1980) and the symmetry span task (spatial working memory; Redick et al., 2012), and the processing of emotional information was measured using IGT (Bechara et al., 1994) and TAS (Bagby et al., 1994; Joukamaa et al., 2001).

The results showed that in the masking condition, readers seemed to compensate for their inability to retrieve text content by looking back specifically to an ironic statement by investing extra effort during first-pass reading. The results also showed that the need for re-accessing the ironic statement was mediated by spatial working memory. Readers with lower spatial WMC were more likely to re-access the text content. Readers with lower spatial WMC showed increased look-back to ironic target sentences in the no-masking condition, but longer first-pass rereading in the masking condition. On the other hand, the processing of ironic target sentences remained relatively similar across masking and no-masking conditions for readers with high spatial WMC. However, readers with high spatial WMC did more look-backs to ironic target sentences in the masking condition than they did to literal target sentences. The result suggests that readers with high spatial WMC seem to be able to use look-backs to the utterance location as a cue about the text content. These findings are in line with the *Compensatory-Encoding Model* (Walczyk & Taylor, 1996) that states that readers with low WMC use text as external memory and utilize

compensatory strategies by initiating look-backs or slowing down their reading, for example.

Overall, the results suggest that, although look-backs provide an opportunity to re-examine the text contents when resolving irony, they are not necessary for successful comprehension of irony. Because readers were able to change their reading behavior in response to the text mask manipulation, the results suggest that readers are already aware of the ironic nature of an utterance during first-pass reading. However, it seems that re-inspecting the ironic utterance either during first-pass reading or during look-backs is important for the formation of the ironic interpretation. Moreover, an additional analysis, carried out in response to a suggestion by one of the reviewers, showed that look-backs initiated from the ironic target statement were related to poorer irony comprehension. The result seems to suggest that the need for a reader to return to previous parts of the text after reading the ironic statement reflects confusion about the possible interpretation of the utterance. Thus, not all of the rereading seems to support the comprehension of irony. The result is in line with the suggestion of Gibbs and Colston (2012) that a failure to integrate the utterance with the context is one of the reasons why a reader might not understand a sarcastic comment.

In line with Studies II and III, the results showed that the ability to recognize emotions was related to the efficiency of resolving irony. Readers who were better able to recognize emotions invested less processing effort to form an ironic interpretation, suggesting that readers who are better able to recognize the intended emotional message in irony are faster to categorize the utterance as ironic.

Finally, the results demonstrated that ironic utterances received longer look-backs from the spillover region in the beginning of the experiment, implying increased sentence wrap-up processing (e.g., Rayner, Kambe, & Duffy, 2000). Moreover, readers showed slower responses to inference questions after ironic versus literal texts; however, this effect wore off towards the end of the experiment. The results partly replicate the findings of Studies II and III, showing that some effects related to the processing of ironic utterances changed during the course of experiment. This suggests that after encountering several paragraphs containing irony during the course of the experiment, readers form an expectation for irony, which facilitates the processing of it.

# 3. Discussion

The purpose of the present thesis was to explore 1) how readers resolve the meaning of written irony; 2) what are the individual differences in the processing of written irony; and 3) how the processing of irony compares to the other forms of non-literal language, namely, metaphors. Next, I will discuss the findings of the studies, the theoretical implications, the limitations of the studies, and suggestions for future directions of research on irony.

## 3.1. How Readers Resolve the Meaning of Written Irony

The results of the studies showed that when the context does not signify forthcoming irony and the ironic utterance itself is not conventional, the processing of written irony takes more time to process and is harder to comprehend than its literal counterparts (Gibbs, 1994a; Giora, 2003; Grice, 1975; Pexman, 2008). Across the studies, verbal irony produced mainly delayed effects in the eye-movement records of readers typically showing an increased number of look-backs to ironic target utterances (Studies I-IV) and an increased number of look-backs from the ironic utterance to the prior context (Studies II-IV). These findings are in line with previous eye-tracking studies that have shown increased total reading times[4] for ironic utterances in comparison to literal target ones (e.g., Au-Yeung et al., 2015; Filik et al., 2014; Filik & Moxey, 2010; Turcan & Filik, 2016) and longer total reading times for the context sentences of the ironic texts (Filik & Moxey, 2010). It has been suggested that longer look-backs at the text would reflect an effort to build a comprehensive mental representation of the main textual contents (Hyönä et al., 2002). Readers have been shown to be aware of their look-backs, suggesting that it is a form of strategic reading behavior (Hyönä & Nurminen, 2006). Based on the theoretical views on verbal irony, it may be claimed that the look-back behavior

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[4]  Total reading time is a summed duration of all fixations landing on a text region. Although it contains both first-pass and second-pass fixations, it is generally taken as an indication of relatively late processing (Liversedge et al., 1998; Rayner, 1998; 2009).

reflects the integration of the utterance meaning with the context (see e.g., Gibbs & Colston, 2012, for a review).

However, the results of Study III indicate that the slowdown related to the processing of the ironic utterances is only partially due to irony itself. The results suggest that, at least to some extent, the extra processing is related to the local inconsistency formed by the ironic utterance, and may reflect a reader's confusion when s/he encounters a coherence break in the text. Moreover, the results of Study IV indicate that look-backs might not be necessary for successful irony comprehension; during the first-pass reading of the ironic target utterance, readers were at least already aware that the target statement did not fit in the context. Thus, readers are already able to start processing the new ironic meaning (vs. the literal meaning) of the utterance during the first-pass reading, when they are forced to do so, for example, by preventing later rereading by masking, as in Study IV. However, the results suggest that to understand the ironic meaning, some kind of reprocessing is needed. Furthermore, additional analysis showed that an increased number of look-backs initiated from the ironic statement is associated with poorer irony comprehension. Thus, these look-backs probably reflect the confusion of the reader when the ironic utterance does not fit in the previously read context and the reader is not able to form a suitable interpretation for the utterance.

Across the studies for the present thesis, the results also showed increased first-pass rereading times for ironic target utterances. However, first-pass rereading was always related to individual difference measures, typically to WMC (Studies I, II, and IV). Moreover, the findings of Study IV indicate that readers with higher spatial WMC might not need look-back to the ironic target utterance to revisit the textual information, as the others do. Individual differences will be discussed in more detail in the next chapter.

The results of Studies II–IV also (interestingly) demonstrated that some of the effects related to the processing of verbal irony changed during the experimental session (see also Spotorno & Noveck, 2014). The results suggest that participants had become sensitive to irony during the experiment, and that the observed effects may depend on the amount of prior exposure to irony. It is possible that the observed order effects are similar to syntactic priming effects. In syntactic priming, the presentation of a syntactic structure facilitates the comprehension of subsequent similar structures (see e.g., Traxler, Tooley, & Pickering, 2014). It is also possible that the ironic utterances encountered during the experiment create a global context emerging from the different stories that supports the ironic interpretation.

The results showed that ironic utterances were harder to comprehend than their literal counterparts, as reflected by lower accuracy scores for the inference questions asked after the texts had been read (Studies I–IV). It seems that despite the extra effort invested in the processing of irony, readers do not always understand the true

meaning of irony. They also took longer to respond to the inference questions after ironic texts than they did to those following the literal texts (Study IV). The result may indicate that readers need more time to validate their answer after ironic texts.

## 3.2. Individual Differences in Processing Written Irony

### 3.2.1. Working memory capacity

The results of the studies of this thesis demonstrated that there are individual differences in the processing of verbal irony related to WMC. Higher verbal WMC was already related to an increase in the processing times of the ironic target statements during the first-pass reading (Studies I, and II). These findings are in line with a suggestion by Giora (1999) that readers with higher WMC would be better at suppressing the salient literal meaning, and thus can already start processing the intended meaning during the first-pass reading of the utterance. However, the results of Study III showed that when the ironic utterances were embedded in relatively short (3–4 sentences long) paragraphs, this effect was not found. The pattern of results obtained in Studies I–III suggests that readers might have to inhibit not only the more salient literal meaning, but also the irrelevant text context that is not critical for the interpretation of the ironic utterance. In other words, it seems that when there is a minimal amount of or no irrelevant context (only 1–2 sentences) that needs to be inhibited during the interpretation formation, individual differences related to WMC disappear.

Furthermore, the results indicate that readers with lower WMC need to rely more on external memory – the text itself. As shown in Study II, readers with low WMC were more likely to look back to ironic target utterances from the other parts of the text. In addition, the results of Study IV showed that readers with lower (spatial) WMC needed to compensate when they were not able to retrieve textual information during the second-pass reading (i.e., by looking back at text) due to masking, and they slowed down during the first-pass reading. The results are in line with *the Compensatory-Encoding Model* (e.g., Walczyk & Taylor, 1996). The model suggests that readers with low WMC are bound to use text as external memory and apply compensatory strategies, such as looking back or slowing down their reading.

Finally (and surprisingly), the results of Study IV showed that readers with high spatial WMC also made look-backs to the ironic target utterances when the ability to retrieve textual information by looking back was restricted by visual masking. As suggested by the former research literature, readers build a spatial representation of the text layout while reading (Baccino & Pynte, 1994; 1998; Kennedy et al., 2003; Murray & Kennedy, 1988), which aids readers to direct regressive eye movements, such as look-backs, accurately towards an intended text location (Kennedy et al.,

2003). Moreover, it has been suggested that returns in text would reflect a need to focus attention on what had appeared there (Meseguer et al., 2002), and that the re-activation of the memory representation sometimes drives the eyes to already-viewed locations (Ferreira et al., 2008). Thus, it seems that for readers with higher spatial working memory, look-backs work as cues about the text content: They made look-backs to the ironic statement even when it was masked. In other words, it is possible that they are better at maintaining in their mind an episodic memory representation that contains both the text content and the spatial information. Thus, look-backs to previous parts of the text help them to retrieve the content information from memory.

## 3.2.2. The ability to process emotional information

Pre-tests for Studies II and III showed that there is an emotional component in the verbal irony. Irony (at least the sarcastic irony that was used in these experiments) is experienced as negative/as an insult (Study II and III), but also as funny (Study III), which is in line with previous studies (Akimoto et al, 2014; Bowes & Katz, 2011; Dews et al., 1995; Gibbs & Izett, 2005; Jorgensen, 1996; Kreuz et al., 1991; Leggitt & Gibbs, 2000; Winner & Leekam, 1991). Therefore, it is not surprising that the results of these studies showed that the ability to process emotional information is related to the processing of written irony (Studies II–IV).

The results showed that a better ability to process emotional information is related to less processing time invested in the ironic target statements (Studies II; IV). Moreover, those with a poorer ability to process emotional information showed increased processing times for the paragraphs containing an ironic utterance. These results are in line with the constraint satisfaction framework (Pexman, 2008) in suggesting that the emotional message delivered by the ironic statement works as a supporting cue for ironic interpretation. Consequently, readers with a better ability to process emotional information are faster at processing ironic meanings. On the other hand, it seems that those with a poorer ability to process emotional information need to have their interpretation rely more on the textual context, as suggested by the increased processing of contextual information in textual paragraphs containing an ironic utterance.

It should be noted that the effects related to the processing of emotional information were relatively small across the studies for this thesis. However, the effects were found consistently across the studies, suggesting that the ability to process emotional information can support and contribute to the processing of verbal irony.

## 3.3. Differences in Comprehending Irony versus Metaphors

The results of Study II showed that the processing of irony differs from the processing of metaphors: The processing of metaphors was characterized by slowdown during first-pass reading of the utterances, whereas irony produced mainly delayed effects in the eye-movement records. Ironic statements were also harder to comprehend than literal or metaphorical utterances, as indicated by the poorer performance on responses to inference questions. As noted in the introduction, the comprehension of metaphors requires the reader to find commonalties between the topic and the vehicle from his/her memory, whereas irony comprehension requires the reader to integrate the utterance meaning with the context where it appears (see e.g., Colston & Gibbs, 2002; Pexman et al., 2000; Winner & Gardner, 1993).

As for the individual differences, WMC affected the processing of both irony and metaphors: low WMC was related to an increase in look-back to the metaphorical and ironic statements. The results indicate that integrating the utterance meaning with the context (i.e., comprehension of irony) and finding commonalties with two or more concepts (i.e., comprehension of metaphors) requires from the reader an ability to manipulate information in his/her mind to achieve a correct interpretation (i.e., working memory). However, the ability to process emotional information was only related to the processing of irony and not to that of metaphors, suggesting that the emotional component in verbal irony (non-existent in metaphors) makes irony different from literal or metaphoric language.

## 3.4. Theoretical Implications

In general, the findings of the studies for the present thesis are in line with most current theories on irony comprehension. The theories state that ironic utterances are harder to process and comprehend than their literal counterparts, when the context does not provide advance cues for an ironic interpretation (Gibbs, 1994; Pexman, 2008) and when the utterance is not typically used as ironic (Giora, 2003; Grice, 1975). Under these conditions, readers are likely to adopt a literal meaning; so, in order to comprehend the utterance correctly, they need to reassess its meaning (Giora, 2003; Grice, 1975). However, the current theoretical views do not make precise enough predictions on how different factors affect the processing of written irony and how individual differences affect the processing of written irony. Based on the current theoretical evidence, and mostly on a parallel constraint satisfaction framework (Pexman, 2008), the empirical evidence on irony comprehension, and the findings of the studies for the present thesis, I suggest a new model: the *Cumulative Evidence Model* (CEM) of irony comprehension (see Figure 1).
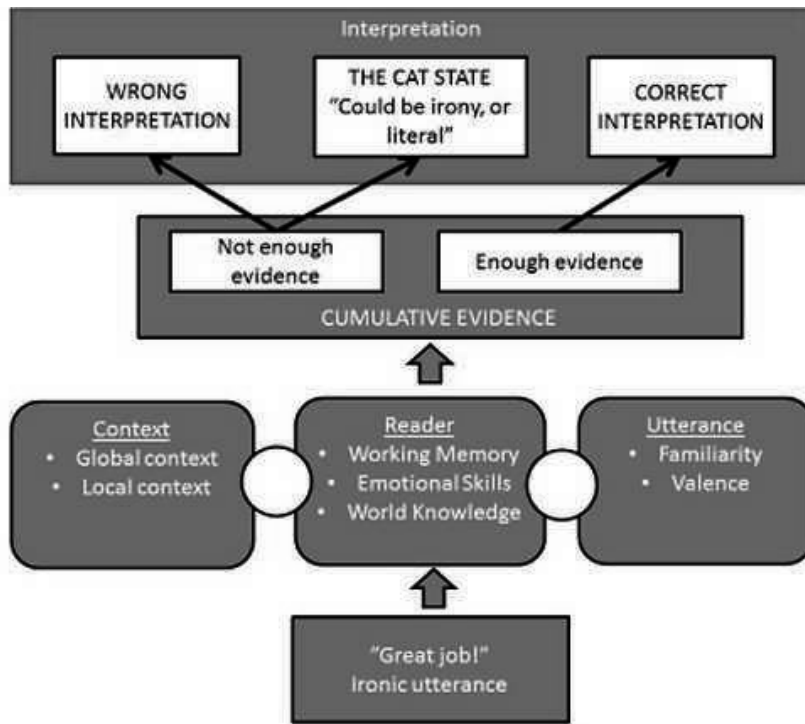
*Figure 1*. The Cumulative Evidence Model of irony comprehension.

The core idea of the model is that because the very nature of irony lies in the contrast between the literal form of the ironic utterance and the context in which it is presented, the ironic utterance is typically not expected. Hence, it needs more time to process. The results of the studies for this thesis have shown that the extra processing time needed in resolving the intended meaning is seen as a reprocessing of the ironic target utterance itself. This is seen in the rereading measures (i.e., first-pass rereadings, look-backs, and look-froms). However, cumulative evidence for the ironic interpretation can reduce ambiguity or the level of surprise related to the ironic utterance, which results in less reprocessing of the ironic utterance. In an extreme case, irony is expected and does not need any extra processing in comparison to its literal counterpart. On the other end of the continuum, if there is not enough evidence for ironic interpretation, the utterance is misunderstood (see also Kruger, Espley, Parker, & Ng, 2005). In the model, I make the assumption that the context in which the ironic utterance appears, the utterance itself, and the reader-related factors contribute to the evidence all accumulating toward an ironic interpretation and thus affect the ease of interpreting the intended meaning of the utterance.

Context effects are divided into local and global. By local context, I mean, for example, the textual context given before the target utterance. The evidence given in

the local context can reduce the amount of ambiguity of the ironic utterance (see also Pexman, 2008). An extreme example of this would be a statement prior to the ironic statement explaining that what the protagonist says next is going to be ironic. I believe that in this kind of extreme setting, the processing time for the ironic utterance would be the same as for its literal equivalent. Moreover, the ease with which the critical cues for the ironic interpretation can be accessed should make the comprehension of the ironic meaning easier and, consequently, faster. For example, the relative closeness of the critical cues to the ironic utterance (Ackerman, 1982) and the quantity of other text not specifically related to the ironic interpretation are assumed to influence the interpretation formation (see e.g., Study III).

Global context, on the other hand, refers to the wider context in which the local context and the ironic utterance appear. For example, the previously read texts can form the global context. If the reader repeatedly encounters ironic utterances in the same situation (i.e., within the same experiment), there will be an expectation of forthcoming irony, which, in turn, reduces the level of confusion potentially caused by irony. This could be seen as reducing the time the reader needs to arrive at an ironic interpretation compared to the first encounters of the ironic utterances in the same situation.

As for the utterance-related factors, at the very least, the emotional valence of an ironic utterance (Pexman, 2008), the intensity of an emotional component (Jacob et al., 2016), and the familiarity of an utterance (e.g., Giora, 2003) should work as evidence pointing towards an ironic interpretation and reduce the time needed to achieve the ironic meaning. For example, the study by Filik and colleagues (2016) showed that when an ambiguous sarcastic comment was accompanied by a wink emoticon ;), it reinforced the intended sarcastic meaning[5] (see also Derks, Bos, & von Grumbkow, 2008). Moreover, there is lots of evidence on how word frequency (i.e., the familiarity of a word), reduces the amount of time spent on reading a single word (Rayner, 1998; 2009). Similarly, the more frequently a single utterance appears in the environment as ironic, the faster the reader categorizes the utterance as ironic (see also Giora, 2003). A recent eye-tracking study has also shown that the familiarity of an ironic utterance reduces the amount of time spent to process it (Filik et al., 2014; Turcan & Filik, 2016).

Reader-related factors exert an effect on how the reader processes contextual and utterance-related cues and thus on a reader's ability to make a correct inference. Working memory is related to a reader's ability to deal with contextual information. High WMC readers are able to inhibit the irrelevant contextual information, activate relevant cues, and start processing the ironic meaning as soon as they encounter an

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[5]     It should be noted that whether emoticons serve as representations of a writer's emotions or only as pragmatic markers to clarify an intended meaning is a controversial issue (Skovholt, Grønning, & Kankaanranta, 2014; Thompson & Filik, 2016).

ironic utterance. I believe that the better an individual is in inhibiting irrelevant information, the more efficient s/he is in achieving an ironic interpretation. However, based on the former studies (e.g., Dews et al., 1995) and the results of this thesis I would make a claim that for successful interpretation it is not necessary to completely inhibit other interpretations. Emotional processing abilities are related to a reader's ability to recognize the intended emotional message, which works as an additional cue pointing towards an ironic interpretation (see also Pexman, 2008). I assume that a reader's world knowledge affects the processing of ironic utterances by aiding the reader to recognize, for example, typical situations where irony appears (global context) and typical ironic remarks uttered in certain situations (familiarity), such as typical ironic lines appearing in some TV sitcoms.

The contextual factors, qualities of an utterance, and the reader-related factors together affect how much evidence the reader can accumulate toward an ironic interpretation. If there is enough evidence pointing toward an ironic interpretation, the correct interpretation is achieved. On the other hand, if there is insufficient evidence, the formation of the correct interpretation fails. Yet, if there is some, but not enough evidence, the reader might stay in the *cat state*. I have borrowed the concept of cat state used in quantum mechanics to describe quantum superposition to serve as an analogy for use with understanding irony comprehension when a reader can produce possible interpretation options, but cannot decide which one is the correct one. The cat state typically refers to *Schrödinger's Cat Paradox*, in which (to simplify the thought experiment) a cat is put in a metal chamber with poison that might or might not kill it (Trimmer, 1980). When the chamber remains closed the cat is considered to be simultaneously dead and alive (superposition), but opening the chamber and observing the cat will tip the scale to one of the outcomes (Yam, 2012). Similarly, a reader of ironic statements who is given some evidence so that it is possible to produce an ironic interpretation option, but is not given enough evidence so that s/he can be confident about the interpretation, remains in a state in which both interpretation options seem to be likely interpretations. There could be other options as well, if the evidence in the text supports other possible interpretations (e.g., lies). However, when the reader is forced to decide, one of the interpretation options is chosen. This could explain why in Study IV longer response times were observed for the inference questions posed after ironic texts were read. There is also some evidence pointing out that literal and ironic interpretations can co-exist, at least in some form (e.g., Dews et al., 1995; Filik, Brightman, Gathercole, & Leuthold, 2017); this further suggests that the cat state might exist in the irony comprehension.

## 3.5. Critical Remarks

The studies of this thesis, naturally, had their limitations. First, sarcastic irony was used across the studies (Study I, Exp2; Study II–IV). Sarcasm is a specific subtype of verbal irony. In sarcastic irony, the emotional marker is clearer than in other types of irony because sarcasm is typically meant to criticize someone (e.g., Attardo, 2000). Thus, these results might not generalize to all types of irony, and future studies are needed to explore, for example, the relation between the ability to process emotional information and the ability to process different forms of verbal irony.

Second, two different tasks were used to measure the processing of emotional information. IGT (Bechara et al., 1994) was used in Studies II and IV, and the TAS (Bagby et al., 1994; Joukamaa et al., 2001) was used in Studies III and IV. Both measures demonstrated relatively similar effects in the processing of sarcastic irony, although they should measure different abilities. IGT is thought to measure an individual's sensitivity to emotional responses to reward and/or punishment in a decision-making task. The effect of the emotional response measured by IGT is thought to be, to some extent, unconscious (e.g., Buelow & Suhr, 2009). On the other hand, TAS measures an individual's ability to recognize and name emotions (i.e., alexithymic traits) and should reflect a more conscious emotional processing ability. In Study IV, both measures were used, and the results showed that only TAS was related to the processing of irony. The results also showed that the task scores did not correlate with each other ($r = -0.06$), suggesting that they indeed measure different abilities. The result suggests that the ability to name and recognize emotions might be a stronger predictor of irony comprehension than the automatic activation of emotion. However, this suggestion should be considered with some caution, as the experimental manipulation (masking) used in Study IV might have affected the observed effects. Thus, the nature of individual differences related to the processing of emotional information should be explored in more detail in the future.

Third, the gender distribution was skewed across the studies of this thesis. This possible limitation was pointed out by one of the reviewers of Study IV. Previous studies have shown that men are more likely to use ironic language than women (Colston & Lee, 2004; Gibbs, 2000; Rockwell & Theriot, 2001; cf. Taylor, 2017). However, only a few studies have examined gender differences in the comprehension of irony (Baptista, Macedo & Boggio, 2015; Holtgraves, 1997; Rothermich & Pell, 2015), and most of them have not found differences between males and females in irony comprehension (Baptista et al., 2015; indirect language in general, Holtgraves, 1997). However, some findings have shown that the processing strategy used for understanding irony differs between men and women (Baptista et al., 2015). Moreover, results of the study by Rothermich and Pell (2015) showed that women were better at recognizing sarcasm than men. Thus, the potential gender effects should be taken into account in the future.

## 3.6. Future Directions

The studies for the present thesis raise some interesting questions to be explored in the future. First, the purpose of the present thesis was to explore individual differences in the processing of written irony related to WMC and emotional abilities among healthy adults. The studies for this thesis were the very first to explore the matter, and the results related to the individual differences were exploratory by nature. Thus, in the future, it would be interesting to experimentally manipulate the working memory load and emotional state of readers to further explore the role that WMC and emotional abilities play in irony comprehension.

The results of this thesis have showed for that a global context can also affect the processing of ironic statements. In the future, it would be important to explore the role of the global context by manipulating it more directly; for example, by investigating whether prior exposure to ironic materials or conversations before the actual experiment is enough to create an expectation about forthcoming irony in the experiment and thus facilitate irony processing. Moreover, there are already some studies that have explored the role of the local context in the processing of verbal irony (e.g., Pexman et al., 2000; Turcan & Filik, 2016). However, we still do not know how cumulative evidence about forthcoming irony affects reading times. As predicted by the CEM, the clearer the evidence about forthcoming irony in local context is, the shorter the reading times for ironic statements should be in comparison to those for literal statements. It would be interesting to directly explore this by, for example, examining reading time differences between different strengths of cues (e.g., by comparing an explicit mention of the target statement as ironic to more subtle cues).

Finally, in the present studies, ironic text materials were used that were written by me with the help of my co-authors and colleagues. These materials were controlled for many features; for example, the same target sentence was used as ironic and literal. The advantage of using controlled text materials is that comparable reading times can be obtained for ironic and literal statements when presented out of context (see discussion between Gibbs, 1986, and Giora, 1995). In other words, possible differences in reading times can be ascribed to irony comprehension. However, irony research has been criticized for using artificial settings while studying such diverse social phenomena (see e.g., Katz, 2005). The eye-tracking methodology used in the present thesis would also enable the study of verbal irony processing in more naturalistic settings, for example, by using video clips containing real discourse, or by using written ironic statements published on social media sites.

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