Time-course of meaning activation and hemispheric asymmetries during pun comprehension

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The candidate confirms that the work submitted is his/her own and that appropriate credit has been given where reference has been made to the work of others.

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Et omni iocos meos dedico!

Abstract

This thesis investigates the processing costs and hemispheric asymmetries associated with pun processing as well as the importance of the internal semantic structure of the pun in that process. We used both behavioural and electrophysiological measurements to address these issues. A series of experiments explored the processing costs and hemispheric asymmetries for puns which are motivated by the literal re-interpretation of idioms (e.g., *Old skiers never die, they just go downhill.*) as well as for puns which are motivated by the multiple meanings of ambiguous words (e.g., *The prince with a bad tooth got a crown.*). The overall pattern of the data points to the conclusion that the processing costs associated with pun comprehension are affected significantly by the internal semantics of the pun, namely the more semantically related the two meanings are, the greater the processing demands. Additionally, the data suggest that puns which require more processing costs are more likely to engage the right hemisphere in the comprehension process. The results are discussed in light of bottom-up models of non-literal language processing, namely the standard pragmatic approach (Grice, 1975), the direct access model (Gibbs, 1994) and the graded salience hypothesis (Giora, 2003). We draw the conclusion that none of these models can accommodate the complexity of the data. We suggest that the conceptual blending theory (Fauconnier and Turner, 1998) may be a more suitable model of non-literal language processing and propose ways in which it might be narrowed down enough to provide testable hypotheses in the future.

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Abbreviations

ACC	accuracy
DVF	divided visual field
EEG	electroencephalogram
ERPs	event-related potentials
fMRI	functional magnetic resonance
GSH	graded salience hypothesis
ISI	inter-stimulus interval
LBD	left brain damage
LH	left hemisphere
lvf	left visual field
MEG	magnetoencephalogram
RBD	right brain damage
RH	right hemisphere
RT	reaction time
rvf	right visual field
SOA	stimulus onset asynchrony

Chapter 1. Introduction

The importance of studying figurative language is evident from the sustained interest it has attracted since Aristotle published his *Poetics* (approximately 350 BC). Historically figurative language was conceptualized as deviant from normal literal language used only to fulfill the aesthetic purposes of language. In contrast, the research conducted within cognitive linguistics (e.g., Lakoff and Johnson, 1980) and cognitive science more generally (e.g., Fauconnier and Turner, 2002) has provided evidence to suggest that figurative (metaphoric) thought is a fundamental feature of human cognition and expression. A myriad of investigations established the relationship between metaphor and cognition, the conceptual underpinnings of metaphors, the neural mechanisms of conceptual metaphors as well as the embodied experiences essential for metaphor processing and understanding. Metaphors are only one example of figurative language, but the disproportionate volume of research on metaphor has expanded to such an extent that currently *figurative* and *metaphoric* are seen as interchangeable.

Other figures of speech are largely underrepresented in the area of non-literal language processing with only some tradition in investigating irony (e.g., Regel, Gunter and Friederici, 2010), metonymy (e.g., Nerlich, 2003) and to a lot lesser extent, puns (e.g., Coulson and Severens, 2007). Since one of the main objectives of conducting the present research is to build upon Coulson and Severen's findings about pun processing, we adopt their definition of a pun as 'a *rhetorical technique* in which the speaker *deliberately* invokes *multiple meanings* via a *single word* or *phrase*' (Coulson and Severens, 2007: 3; italics added). The definition is clear and concise and it highlights the three aspects of puns that we will see as central to the construct, namely 1) it positions puns in the context of figurative language by referring to it as a rhetorical technique, 2) it reveals that the multiplicity of meanings in puns is intended by the speaker, and 3) the indication that the multiplicity of meanings can be motivated by either a single word or a phrase. Even though definitions of a pun often mention its humorous aspect as well (e.g., Attardo, 1994; Crystal, 1992), this particular feature of puns is beyond the scope both of Coulson and Severen's paper and our research hence its exclusion from the definition. Research on puns is timely as experimental data can support existing findings and assumptions about non-literal language processing formulated largely on the basis of investigating metaphors thus strengthening the theoretical underpinnings of non-literal language comprehension as well as the implications for human cognition and thought. Data collected

from puns is particularly important as they provide insights into non-literal language processing which few other figures of speech can give us. Essentially, most figures of speech are characterized by an irregular excess of meaning, but ultimately only puns intend to convey that excess of meaning. Whereas metaphors, irony, and metonymy intend to communicate only one meaning, puns go a step beyond that as they intend to convey more than one meaning simultaneously. Investigations with puns will have important implications for understating our cognitive abilities to entertain more than one intended meaning in a conflicting yet coherent framework akin to optical illusions, as well as the hemispheric preferences for processing such examples of non-literal language. More practically, since language skills are an important social tool, findings from pun processing might be applied in fields aiming to develop intervention strategies for different types of language impairments and/or the re-integration of brain damaged populations into everyday life. Even though it seems that investigations on puns have important theoretical and practical implications, to date the literature on pun processing is sparse.

The two key questions that research on non-literal language comprehension has attempted to resolve are (i) whether processing non-literal language is more taxing relative to processing literal language, and (ii) to what extent the right hemisphere is involved in non-literal language processing. All the studies on pun processing included in this thesis attempt to further illuminate these two key questions. According to Aarons (2012) puns can exploit the inherent linguistic ambiguities evident in phonological, morphological, syntactic and semantic units of language. A closer look at the materials Coulson and Severens (2007) used in their research indicates that their puns exploited predominantly semantic units of language. Hence this thesis focuses on semantic ambiguities and especially those which are realized in puns exploiting the inherent excess of meaning in idiomatic expressions (e.g., '*Old cleaners never die, they just **bite the dust.'*** and '*Old skiers never die, they just **go downhill***.') as well as ambiguous words (e.g., '*You pay your psychiatrist with a sanity **check***.' and *'The prince with a bad tooth got a **crown***.'). Even though Coulson and Severens did not categorise their puns into two groups – puns motivated by idioms and puns motivated by ambiguous words - we argue that this is a necessary procedure as deliberately invoking the two meanings of *a single word* and invoking the two meanings of *phrases* is likely to follow different processing patterns, which may obscure important implications for pun processing if the underlying motivating structure is not taken into account.

We begin our research on puns addressing the first key question. The first part of the thesis comprises of four experiments which explore the time-course of double meaning activation and the role of the internal structure of the pun in that process. Experiments 1 and 2 (**Chapter 2**) address the early and late stages of processing puns which are motivated by the internal ambiguity in idiomatic expressions. Similarly, experiments 3 and 4 (**Chapter 3**) investigate the early and late stages of processing puns which are motivated by the inherent excess of meaning evident in ambiguous words. In the second part of the thesis we present four more experiments which explore the hemispheric asymmetries for pun processing. In particular, experiments 5 and 6 (**Chapter 4**) focus on the hemispheric asymmetries in the early and late stages of processing for puns motivated by idioms, whereas experiments 7 and 8 (**Chapter 5**) focus on the same questions concerning puns motivated by ambiguous words. Lastly, Experiment 9 (**Chapter 6**) presents electrophysiological data which addressed the automatic processing of puns motivated by idioms thus also attempting to provide some insights into the neural correlates of pun processing. Before we present the experimental studies, we review the relevant literature concerning inter-hemispheric and hemispheric processing of non-literal language, idioms and lexical ambiguity.

1.1 Inter-hemispheric processing and time-course of meaning activation

The first key issue addressed in the thesis is the time-course of meaning activation for the dual nature of the pun. The main purpose is to provide experimental evidence regarding the processing costs required in pun comprehension as well as what role the semantic units of language motivating the pun play during comprehension. Since the puns we focus on in this thesis are motivated by the inherent ambiguity between the literal and idiomatic meanings of idioms, and that between the dominant and subordinate meanings of ambiguous words, the following sections will briefly outline relevant research carried out in the area of time-course of meaning activation for non-literal language, in particular idioms and lexical ambiguity resolution.

1.1.1 Time-course of meaning activation for non-literal language: early models

The earliest model of non-literal language comprehension originates from pragmatic theories of meaning and was subsequently labelled *the standard pragmatic approach*. According to Grice's Co-operative Principle, which lies at the heart of that approach, conversation is governed by four maxims that need to be jointly observed by the participants. In an exchange, speakers have to give enough information (*Maxim of Quantity*) that has to be truthful (*Maxim*

of Quality) and relevant to the topic (*Maxim of Relation*), as well as delivered in a clear, precise and unambiguous manner (*Maxim of Manner*) (Grice, 1975). This theory regards non-literal expressions as examples of violations of some of these maxims. For example, puns are mostly seen as violating the maxims of manner and quantity, but under certain conditions they could be violating the maxims of quality and relevance too. Grice (1975) argues that in cases in which a maxim is violated an implicature is created; however, listeners are nonetheless still expected to be able to uncover the intended meanings as we are rational creatures. The implication of this model for processing the intended non-literal meanings is that non-literal meanings are generated from a primary literal meaning that the expression has. In other words, a literal meaning always enjoys an unconditional priority, while the non-literal language is seen as defective (Glucksberg, 2003). Within this early framework, non-literal language comprehension is completed in three stages, which aligns with the assumptions of a modular access to mental representations. In the context of this thesis modularity will be understood as the view that assumes lexical processes are unaffected by non-lexical/contextual information; in other words, lexical processes are impervious to cues from the preceding context, regardless of whether access is serial or parallel. The link between the standard pragmatic approach to non-literal language processing and this view of modularity is often made explicit in the literature (e.g., Gibbs, 2001; Giora and Fein, 1999). The same view of modularity is held in the discussion on idiom processing and lexical ambiguity resolution in the relevant sections below. Each encounter with non-literal meanings begins with an attempt to understand the utterance literally. In the second stage, the utterance is found to be impossible (or defective in some way) in the given context, which triggers the initiation of the third stage – a search for an alternative interpretation that is compatible and appropriate under the given circumstances. If this indirect way of processing figurative language has psychological reality, psycholinguistic experiments would indicate that it requires more cognitive effort to reach the intended secondary meaning via the primary literal one. Blasco and Connine (1993) admit that such an assumption is only viable if the three stages suggested by the model are to occur temporally one after the other. Evidence in support of the standard pragmatic approach comes from measuring reading times in off-line comprehension tasks which indicate that reading metaphoric statements requires longer than reading literal statements (e.g., Blank, 1988; Gerrig and Healy, 1983; Ortony, Schallert, Reynolds, and Antos, 1978; Shinjo and Myers, 1987). Additionally, the standard pragmatic approach receives support from investigations on irony (e.g., Giora, 2003; Schwoebel, Dews, Winner and Strinivas, 2000) as well as proverbs (Temple and Honeck, 1999; Honeck, Welge and Temple, 1998). More recently, reporting more negative

amplitudes for the N400 component and more positive amplitudes for the P600 component after non-literal stimuli compared to literal ones, electrophysiological investigations also provide evidence in support of the standard pragmatic approach (e.g., Coulson and Van Petten, 2002; Coulson and Van Petten, 2007; Lai, Curran, Menn, 2009; Pynte, Besson, Robichon and Poli, 1996).

However, not all experiments consistently reported evidence of greater cognitive effort related to non-literal language processing. For example, Gibbs (1979) asked participants to read indirect requests either embedded in context or presented on their own in single isolated sentences. The results indicated that people took less time to understand the indirect requests when they were presented in context. This early experiment suggested that people need not construct a literal meaning first, only to reject it later in order to arrive at a non-literal one. Indeed it implied that if non-literal language is used in rich contexts biasing the non-literal meaning, it can be accessed directly without relying on the preliminary processing of literal meanings first. Similar results were interpreted as indicating that non-literal language processing is not more effortful than literal language processing (Gibbs, 1994; Gildea and Glucksberg, 1983; Glucksberg, Gildea and Bookin, 1982; Glucksberg, 2001; Keysar, 1989; Keysar, 1994). Electrophysiological data supporting the same interpretation has also been reported (e.g., Balcone and Amenta, 2010; Iakimova, Passerieux, Laurent and Hardy-Bayle, 2005). The body of research presenting such results gave rise to what has become known as *the direct access model* for non-literal language processing (for a critical description of the direct access model see Gibbs, 1994). The direct access model is an example of an interactive, non-modular way of accessing mental representations that assumes contextual information can affect lexical access. In sum, it was suggested that under certain conditions, such as use of strongly biasing contexts, non-literal meanings could be accessed directly without any preliminary stage of rejecting a possible literal interpretation. Subsequent research in this area outlined a number of possible factors that might be crucial for inducing a direct access to non-literal language during on-line processing. The most relevant factors are the presence/absence of strong context (e.g., Keysar, 1994), the conventionality and familiarity of the non-literal meanings (e.g., Lai et al, 2009; Titone and Libben, 2014) and the automaticity of language processing (e.g., Giora and Fein, 1999).

1.1.2 The Middle-ground: the Graded Salience Hypothesis

In an attempt to make sense of the disparate results presented in the previous section, Giora (1997; 2003; 2012 and elsewhere) proposed a new hypothesis aimed at explaining the existing

data better and formulating more accurate predictions about non-literal language processing. The *graded salience hypothesis* (henceforth GSH; Giora, 1997) is a middle-ground model that is more consistent with modular views of accessing mental representations but at the same time it diverges from them on two important accounts. While it argues that access is modular, it also claims that activating mental representations is ordered according to the degree of salience of the stimuli. The graded salience hypothesis further argues that context has a predictive power whose effects are independent from lexical access but run parallel to it. Therefore, it proposes a middle-ground model of non-literal language processing which takes into consideration lexical factors such as saliency, as well as accepting the importance of contextual bias.

According to the GSH (Giora, 1997; 2012), the salience of linguistic expressions is a function of their familiarity, conventionality and meaning dominance. The notion of salience is not an all-or-nothing matter, but rather it allows for different degrees, namely salient, less salient and non-salient. A meaning is salient if it is coded in the mental lexicon and scores high on variables such as prototypicality, stereotypicality, familiarity, conventionality and frequency of use. A less salient meaning is also coded but it scores lower on the same variables. A non-salient meaning is one that is not coded but is novel and constructed in the discourse. Giora (1997) introduced the notion of salience as different from and independent of literality or figurativeness. A meaning can be salient and literal, but it can also be salient and figurative (e.g., within the framework of the GSH, the non-literal meaning of idioms is considered the salient one). Also, non-salient meanings are not necessarily non-literal; they could be literal too. Giora (2012) calls these cases 'optimal innovations'. For example, a slogan for a shoe shop which reads *Body and sole* is one such optimal innovation because the coded salient meanings of sole/soul interact in a novel way resulting in non-salient meanings. Two further examples discussed by Giora (2012) are *know hope* (in which there is an interplay between know and no) and *curl up and dye* (with an interplay between dye and die which is considered apt for the name of a hair salon). Hence with the introduction of salience, Giora (2012) aims to resolve the inconsistency in studies which investigate the processing differences between more and less conventional forms of non-literal language. Making explicit the relationship between saliency and coding in the mental lexicon, Giora (2003) argues that the degree of salience of linguistic stimuli is what constrains lexical access. To be more specific, the GSH predicts that the salient meanings will be activated first, followed by the less salient meanings while the non-salient ones will be activated last. Furthermore, the GSH also makes predictions for hemispheric

asymmetries during non-literal language processing with the less salient meanings exhibiting a right hemisphere involvement.

As far as the role of context is concerned, the GSH assumes a predictive role for contextual information. Peleg, Giora and Fein (2001) presented results which showed that a very rich and supportive context can activate meanings on its own independently from the lexical access processes. As a result, it could be expected that there are cases in which salient meanings are activated due to their salient status in the mental lexicon but they are contextually inappropriate. However, the activation of these meanings cannot be suppressed because context effects and lexical access processes are separate and independent from each other; thus, context will not inhibit salient inappropriate meanings, it will, however, enhance less salient but appropriate meanings. Even though Giora (2012) admits that the GSH makes predictions mostly about the early stages of automatic processing, she further claims that salient but contextually inappropriate meanings may be maintained active in case they are required in a later stage of re-analysis. Thus, non-literal language comprehension, according to the GSH, is guarded by two processes which run parallel to each other. More specifically, lexical access is modular but sensitive to the coded, salient information of the stimuli with salient meanings being accessed first, irrespective of any contextual information. Simultaneously, context may help facilitate the activation of a less salient or non-salient meaning by virtue of its predicative power, but it cannot inhibit the activation of salient meanings. The graded salience hypothesis finds support both from behavioural investigations (e.g., Giora, 1997) as well as studies employing electrophysiological measures (e.g., Arzouan, Goldstein, and Faust, 2007b**;** De Grauwe, Swain, Holcomb, Ditman and Kuperberg, 2010; Laurent, Denhieres, Passerieux, Iakimova, Hardy-Bayle, 2006).

1.1.3 Time-course of meaning activation for idioms

Idioms are wide-spread in the English language and researchers are largely in agreement that they are fixed and stable combinations of words whose overall meaning is different from the sum total of the meanings of the individual words comprising them (e.g., Glucksberg, Brown, and McGlone, 1993). The traditional approach to idiom processing considers idioms as fixed expressions whose idiomatic meaning is stored in the mental lexicon and is retrieved as a whole during language comprehension. There are two influential models that fall into this category, namely the *lexical representation hypothesis* (Swinney and Cutler, 1979) and the *direct access model* (Gibbs, 1980, 1994). According to the lexical representation hypothesis both literal and idiomatic meanings are activated in parallel during on-line idiom processing,

whereas according to the direct access model only idiomatic meanings are accessed. Both of these models are known as lexical, or non-compositional models of idiom processing, because both of them assume that the activation of the literal meanings of the idioms' components either plays no role for the activation of the idiomatic meanings or are bypassed altogether in that process. In other words, lexical models of idiom processing assume that processing the idiomatic meanings of idioms is independent of processing the literal meanings of idioms. These models align with an interactive, non-modular access to the mental lexicon as they assume that idiomatic meanings are accessed directly without an obligatory first stage of accessing literal meanings.

An alternative view of idiom processing suggests that idioms are processed following the mechanisms used during literal language processing; in other words, idioms are processed in a compositional manner (Boulenger, Hauk and Pulvermuller, 2009; Cacciari and Tabossi, 1988; Canal, Vespignani and Cacciari, 2010; Cutting and Bock, 1997; Holsinger and Kaiser, 2013; Holsinger, 2013; Papagno, Oliveri and Romero, 2002; Peterson, Burgess, Dell and Eberhand, 2001; Sprenger, Levelt and Kempen, 2006; Titone and Connine, 1999; Zempleni, Haverkort, Renken and Stowe, 2007). For example, according to Cacciari and Tabossi (1988), idioms are processed initially as free combinations of words until a certain point in the idiom, known as the idiom's key, is reached allowing the particular idiomatic meaning to be activated and retrieved. According to this view, the processing of the idiomatic meanings (i) is dependent on and (ii) follows initial literal processing. As a corollary, the idiomatic meaning has a slower time rise relative to the rise of literal meaning. Generally, it is not available at the offset of an idiomatic expression, especially if the idiom is not predictable or familiar enough (Cacciari and Tabossi, 1988; Caillies and Butcher, 2007). Both studies (Cacciari and Tabossi, 1988; Caillies and Butcher, 2007) report that idiomatic meanings are activated at, or after, 300ms after the end of an idiom. Hence, the obligatory early activation of literal meanings aligns this view of idiom processing more with modular, exhaustive approaches to the mental lexicon.

Based on the growing literature which shows the importance of the literal meanings during on-line processing of idioms, but also taking into account the predictions of the lexical approaches to idiom processing, Cutting and Bock (1997) proposed the *hybrid representation hypothesis*. According to this hypothesis, idiomatic meanings are linked to the lexical-conceptual level of the mental lexicon in a similar way to words, but at the same time access to that level is mediated via the individual components of the idioms. Cutting and Bock (1997) argue that this hypothesis of idiom representation accounts both for the word-like nature and the structure-

like properties of idiomatic expressions, thus attempting to reconcile the interactive, non-modular and the exhaustive, modular approaches for accessing idiomatic meanings in the mental lexicon.

One important experimental manipulation that is considered to be able to induce either an interactive or exhaustive access to idiomatic meanings is biasing sentence context (for contexts effects during on-line idiom processing see for example, Colombo, 1993; Fanari, Cacciari and Tabossi, 2010; Holsinger, 2013; Holsinger and Keiser, 2013). For instance, Holsinger (2013, Experiment 2) investigated participants' eye-movements while they were listening to sentences which either biased the literal interpretations of idioms, or the idiomatic interpretations. Each trial in this experiment began with participants reading aloud 4 target words displayed on a screen – an idiomatically-related target; a literally-related target and two unrelated distractor words. For example, for an idiom such as *kick the bucket* the idiomatically related target was *death,* the literally-related target was *foot*, and the two distractor words *triangle* and *animal.* After they read all words, participants pushed a button indicating the beginning of the audio sentence. The researchers investigated the patterns of eye movements to the target words while participants were listening to the sentences. The results showed that for the literally biased sentences, participants looked at the literally biased words more often compared to the distractor baseline. Conversely, for the idiomatically biased sentences, participants looked at the idiomatically biased words more often relative to the baseline, but in addition looks to the literal targets were also significantly more frequent relative to the baseline especially at the early stages of processing the sentence. Holsinger (2013) argued that context can modulate the activation patterns for the literal and idiomatic meanings even though the literal meanings seemed to be activated even in contexts which primed the idiomatic meanings. Holsinger (2013) further argued that the pattern of data is compatible with the predictions of the hybrid representation hypothesis, which holds that the literal meanings of the component words in idiomatic expressions are functional for accessing the idiomatic meanings and are obligatorily activated during on-line idiom comprehension. In sum, even though the literal meanings are activated by default, strong idiomatic contexts can successfully guide direct access to idiomatic meanings, whereas literally biased contexts guide access only to literal meanings.

The processing models discussed so far were largely developed without explicit consideration of the multi-dimensional nature of idioms. According to Libben and Titone (2008), idioms vary along a wide variety of dimensions some of which are familiarity, predictability,

decomposition, literal plausibility, ambiguity, semantic opacity, grammatical well-formedness, and syntactic flexibility. Of particular importance for the current thesis is idiom decomposition. According to the *idiom decomposition hypothesis* (Gibbs and Gonzales, 1985; Gibbs and Nayak, 1989, Gibbs, Nayak and Cutting, 1989, Gibbs, Nayak, Bolton and Keppel, 1989, Gibbs, 1992, Gibbs, Bogdanovich, and Sykes, 1997) idioms can be decomposable (either normally decomposable or abnormally decomposable) and non-decomposable. Gibbs et al (1989a) explained that if an idiom is normally decomposable, meanings of the components of the idiom contribute in an obvious way to the overall idiomatic meanings. For example, it is easy for people to see how the idiomatic meaning of '*pop the question'* is evenly distributed over the idioms' components 'pop' (instead of 'ask') and 'question' (standing for one particular type of question). If an idiom is abnormally decomposable, the relationship between the meanings of the idioms' component words and their figurative expression must be motivated by a metaphor. For example, '*carry a torch for someone'* is abnormally decomposable by virtue of the conventionalized metaphoric relationship between *a torch* and *a warm feeling*. Lastly, for an idiom to be classified as non-decomposable, it should be relatively hard for people to see how the idiomatic meaning is distributed over the meanings of the component words. The classic example of a non-decomposable idiom is *'kick the bucket'* because the idiomatic meaning of '*die*' cannot be derived in any obvious way from the meanings of '*kick*' and '*bucket*' (but cf. Hamblin and Gibbs, 1999).

In a series of experiments, Gibbs et al (1989a) established that people have intuitions about the degree of decomposition of an idiom (but cf. Tabossi, Fanari and Wolf, 2008; Titone and Connine, 1999), and that the degree of semantic decomposition can successfully predict the syntactic and lexical behaviour of most idioms (Gibbs and Gonzales, 1985). Gibbs and colleagues further argued that people process decomposable and non-decomposable idioms differently. In particular, in a phrase verification task, Gibbs et al (1989a) found that people take less time to judge that decomposable idioms are meaningful phrases in English than they do to decide if non-decomposable idioms are meaningful phrases. On the basis of this evidence, the researchers argued that decomposable idioms are easier to process than non-decomposable ones because the default mechanism operating during idiom processing is decomposition which fails to work smoothly for non-decomposable idioms.

To expand these results, Titone and Connine (1999) conducted an eye-tracking experiment to investigate the importance of sentence context during the processing of decomposable and non-decomposable idioms. They found that fixation times on decomposable idioms do not

differ depending on whether the idiom was preceded by disambiguating context or followed by it. On the other hand, the fixation times for non-decomposable idioms were modulated depending on their position in the sentence. Participants spent longer on a non-decomposable idiom when it was preceded by context priming either the literal or the idiomatic meaning of that idiom than when the same context followed the idiom. Titone and Connine (1999) argued that since the literal meanings of the idiomatic expressions are obligatorily activated during on-line idiom comprehension, the dissimilarity between literal and idiomatic interpretations for non-decomposable idioms results in more effortful processing. They further suggested that only idiomatic meanings of non-decomposable idioms are lexicalised in the mental lexicon. However, the psychological reality of idiom decomposition has not gone unchallenged. For example, Tabossi et al (2008) tried to replicate Gibbs and colleague's earlier findings but found no support for the main claims of the decomposition hypothesis. Even more recently, experimental evidence was reported that when decomposable and non-decomposable idioms were used in sentence contexts, decomposable idioms showed a processing disadvantage over the non-decomposable ones (Cieslicka, 2013; Zhang, Yang, Gu, Ji, 2013). Thus, although it is clear that the degree of idiom decomposition plays an important role during on-line idiom processing, it is still an open question under what experimental conditions decomposable idioms might show a processing advantage.

1.1.4 Time-course of meaning activation for lexical ambiguity

With regards to the processing of lexical ambiguity, there are three main models of lexical access in sentence contexts, namely the *multiple exhaustive access model* (Swinney, 1979), the *selective access model* (Simpson, 1981) and the *re-ordered exhaustive access model* (Duffy, Morris and Rayner, 1988; Hogaboam and Perfetti, 1975). Aligning its predictions with modular views for accessing the mental lexicon, the *multiple exhaustive access model* suggests that all meanings of an ambiguous word are activated irrespective of contextual bias. For example, in any sentence context, the ambiguous word 'bank' activates both the meaning of 'financial institution' and that of 'long, high strip of land along a river'. According to Simpson (1984), the strongest form of this model predicts the parallel activation of all meanings to an equal degree. Context becomes important during the later stages of meaning selection and integration (e.g., Onifer and Swinney, 1981; Seidenberg, Tanenhaus, Leiman and Bienkowski, 1982; Swinney, 1979). On the other hand, according to *the selective access model* contextual clues can guide access only to the contextually relevant meaning. For example, the 'financial institution' meaning of 'bank' will not be activated in a sentence which biases the 'strip of land' meaning

of the same word, and vice versa, the 'strip of land' meaning of 'bank' will not be activated in a sentence which biases the 'financial institution' meaning of the same word (e.g., Glucksberg, Kreuz and Rho, 1986; Simpson, 1981). Hence, the direct access model aligns its predictions more readily with the assumptions of non-modular/interactive access to the mental lexicon.

However, according to Simpson (1994), it is highly unlikely that a single experiment could be designed in order to provide conclusive evidence in support of one of these models. According to Duffy et al. (1988), experiments in which the ambiguous word is preceded by neutral context generally favour exhaustive access, while results obtained from experiments in which the ambiguous word is preceded by disambiguating context are less clear as they might favour either exhaustive access, if the disambiguating context is not strong enough, or selective access, if the disambiguating context strongly biases the intended meaning. Simpson and Krueger (1991) reported data which supported this claim. In particular, they found that neutral non-biasing contexts resulted in exhaustive access to all meanings of the ambiguous words, whereas strongly biasing contexts activated only one meaning irrespective of the inter-stimulus interval between prime and target. Thus, we conclude that the strength of contextual bias is an important factor which could induce direct access to the mental lexicon.

Finally, according to *the re-ordered exhaustive access model* (Duffy et al., 1988), the multiple meanings of ambiguous words are exhaustively accessed, but they are accessed in order of their meaning dominance, i.e., their frequency of usage in language. Additionally, preceding biasing context could potentially increase the activation levels of the relevant meaning. For example, according to this model the 'financial institution' meaning of 'bank' will be accessed first by virtue of it being the dominant meaning. If it is seen as incompatible with the given sentential context, the second most frequent meaning will be accessed very quickly after that. According to the re-ordered model, lexical access is exhaustive, but the influence of context is observed in the very early stages of lexical processing, often within the first 200ms of stimuli presentation (Duffy et al., 1988; Klepousniotou, 2007). According to Simpson (1994), the re-ordered access is likely to have a similar outcome to that of the selective access as very often context is compatible with the most frequently used meaning of an ambiguous word. This model also finds support from different methodologies, for example with ambiguity detection tasks (Hogaboam and Perfetti, 1975) and eye-movements (Duffy et al., 1988).

The psycholinguistic models introduced so far are built on the implicit understanding that lexical ambiguity is a homogeneous linguistic phenomenon. However, the literature on theoretical linguistics convincingly argues in favour of fine distinctions within lexical ambiguity

(Cruse, 1986; Lyons, 1977). The two main subtypes of primary importance for the present thesis are the distinctions between homonymous and polysemous words. In particular, whereas the multiple meanings of homonymous ambiguous words are not seen to be meaningfully related to each other, the different senses of polysemous words are seen to be related. For example, *'bank'* is considered a good example of homonymy as the meaning of 'financial institution' is not semantically related to that of a 'long strip of land along a river'. Alternatively, an ambiguous word such as *'mouth'* for example is widely regarded as polysemous as its dominant sense referring to 'a cavity in the lower part of the human face' and the subordinate one referring to 'an opening of a cave' are seen as related to each other (on the basis of metaphoric extension). Even though the theoretical construct of meaning relatedness is fraught with unresolved issues that may lead to instances where ambiguous words are difficult to classify as either polysemous or homonymous, the distinction between the two sub-types of lexical ambiguity is widely respected. More importantly, it received strong and consistent support from psycholinguistic experiments using various methodologies which testifies for its strong psychological validity. For example, a number of behavioural investigations report sense-relatedness effects (Klepousniotou, 2002; Klepousniotou and Baum, 2005a; Klepousniotou and Baum, 2007; Klepousniotou, Titone and Romero, 2008; Rodd, Gaskell, and Marslen-Wilson, 2002; but cf. Klein and Murphy, 2001 who did not find processing differences between homonymous and polysemous words). In particular, in an investigation of the ambiguity advantage effect during word recognition, Klepousniotou and Baum (2007) explored sense-relatedness effects for ambiguous words in isolation. The researchers employed four different types of lexical ambiguity, namely balanced homonyms (i.e., the two unrelated meanings are equally dominant), unbalanced homonyms (i.e., one of the meanings is more dominant than the other), metaphoric polysemy and metonymic polysemy. Klepousniotou and Baum (2007) presented the four different types of ambiguous words as targets in two simple lexical decision experiments (one auditory and one visual). The results obtained from the auditory task bear the most relevance for the current investigation. They indicated that it was only the polysemous words which exhibited a processing advantage relative to unambiguous control words, while homonymous words were processed similarly to the unambiguous control words. In other words, homonyms did not show any facilitation effects. Hence, Klepousniotou and Baum (2007) argued that the ambiguity advantage effects associated with the processing of ambiguous words apply only to ambiguous words whose senses are closely related to each other. The lack of such close relationship between the meanings of the homonymous words explains the lack of facilitation effects for this type of

ambiguity. Furthermore, the differences between polysemy and homonymy have been attested in EEG and MEG studies too (Beretta, Fiorentino, and Poeppel, 2005; Klepousnioutou, Pike, Steinhauer, and Gracco, 2012; MacGregor, Bouwsema, and Klepousniotou, 2015; Pylkkanen, Llinas, and Murphy, 2006; Swaab, Brown, Hagoort, 2003).

However, even though we observe clear sense-relatedness effects during word recognition and during processing ambiguous words in isolation, the effects the different degrees of sense-relatedness have on lexical access during sentence processing are not explored in detail yet. Klepousniotou and Baum (2005b) is the only study of which we are aware to date that employed polysemous and homonymous words in sentential context. However, that study did not show that sense relatedness had any effects on lexical access when the ambiguous words were used as part of sentence primes. Klepousniotou and Baum (2005b) argued that the relationship between the different meanings/senses of the ambiguous words did not influence the activation patterns of these words in the presence of biasing context. Clearly further research is needed in this area in order to support this assumption.

1.2 Hemispheric asymmetries

The second key question the studies in this thesis are addressing is the extent to which the right hemisphere (RH) is involved in the processing of puns, as well as the importance of the internal semantic structure of the double meaning of the pun in that process. RH involvement has been observed for processing non-literal language, idioms as well as lexical ambiguity. The sections below will present the most relevant research in each of these areas.

1.2.1 Hemispheric asymmetries for non-literal language processing

A growing body of evidence has shown that the RH contributes to language processes in an important and collaborative way. It has justified the emergence of concepts like 'the division of labour in the brain' (Coulson and Van Petten, 2007) and even 'the RH hypothesis' (Giora, 2007). The RH has been implicated in processing when a holistic and more pragmatic aspect of language comprehension is required (e.g., Schmidt, DeBuse and Seger, 2007; Schmidt and Seger, 2009). More specifically, the RH is involved in the comprehension of *jokes* (e.g., Coulson and Wu, 2005; Coulson and Williams, 2005; Marinkovic, Baldwin, Courtney, Witzel, Dale and Halgren, 2011; Shammi and Stuss, 1999), *lexical ambiguity* (e.g., Burgess and Simpson, 1988; Burgess and Lund, 1998; Chiarello, 1985; Chiarello, Richards and Pollock, 1992**;** Chiarello and Richards, 1992; Faust and Chiarello, 1998; Faust and Lavidor, 2003; Titone, 1998), *irony* (e.g.,

Giora, 2003; Eviatar and Just, 2006), *sarcasm* (e.g., Briner, Joss and Virtue, 2011); *metaphor* (e.g., Faust and Mashal, 2007; Kacinic and Chiarello, 2007; Mashal, Faust, Hendler and Jung-Beeman, 2008) and *idioms* (Van Lancker and Kempler, 1987, Van Lancker-Sidtis, 2006).

In order to explain the results that indicate RH involvement in the processing of non-literal language, Beeman (1998) proposed the *coarse semantic coding theory* (see also Beeman, Friedman, Grafman, Perez, Diamond and Lindsay, 1994; and Jung-Beeman, 2005). According to that theory, the two hemispheres have similar representation of semantic information but they differ in the specific dynamics of accessing these stores. More specifically, the LH specialises in the processing of close semantic relations, and activates strongly closely related stimuli implying that this hemisphere carries out a fine processing of the incoming information. On the other hand, the RH specialises in the processing of distantly related aspects of meaning, and weakly activates a broader semantic space implying that this hemisphere carries out a coarse processing of the incoming information. Thus, according to the coarse semantic coding theory, non-literal language processing capitalises on the activations of a wide semantic field with distantly related meanings that are brought together in an innovative and creative way.

However, even though there is a compelling body of evidence in support of the RH hypothesis, it is by no means equivocal and conclusive (e.g., Kacinik and Chiarello, 2007). To be more specific, along with studies reporting results in support of the RH hypothesis for non-literal language processing, there are others which did not replicate them (e.g., Coulson and Severens, 2007; Rapp, Leube, Erb, Grodd and Kircher, 2004; 2007). Arguably, the factor that most often predicts RH involvement is the degree of familiarity, conventionality and novelty of the non-literal language (Kacinik and Chiarello, 2007; Schmidt and Seger, 2009; Yang, 2014). For example, Faust and Mashal (2007) conducted a half-field priming study employing novel metaphors from poetry and consistently found RH involvement. A later fMRI study using the same materials replicated those results (Mashal, Faust, Hendler and Jung-Beeman, 2007). On the other hand, Kacinic and Chiarello (2007) conducted two half-field studies on metaphor comprehension which did not support the RH hypothesis. However, Kacinic and Chiarello (2007) observed priming effects in the RH for literally inappropriate targets when presented after a metaphoric sentence. For example, to understand the metaphoric message in the sentence 'That actress is a flamingo.', a variety of literal concepts such as 'pink' and 'skinny' might be activated. Kacinik and Chiarello (2007) claimed that metaphor comprehension is a complex process which involves the activation, selection and integration of such distinct and seemingly unrelated concepts. The authors concluded that even though the lack of strong

indication for RH involvement was probably due to the fact that they used very simple and familiar metaphors, the study nonetheless supported the coarse semantic coding theory (Beeman, 1998).

In order to reconcile the existing mixed results concerning the involvement of the RH for non-literal language processing, Faust and Kenett (2014) proposed the *cognitive continuum hypothesis*. This hypothesis suggests that differential hemispheric processing for non-literal language is predicted on the basis of the linguistic nature motivating the non-literal language. The cognitive continuum includes a left hemisphere (LH) end, which illustrates the rigid and rule-based processing of familiar and conventional non-literal language processing, and a RH end, which illustrates the chaotic and extra flexible processing of novel and creative instances of non-literal language processing. Differing degrees of familiarity, conventionality and creativity will explain the degree to which the RH is involved. Additionally, very often the greater processing costs required for the more novel, less familiar and more creative use of language are also thought to lead to RH recruitment (e.g., Vigneau, Beaucousin, Herve, Jobard, Petit, Crivello et al, 2011). Thus, even though there is compelling evidence for the RH hypothesis for non-literal language processing, it becomes clear that a closer look at features of the internal semantics of the non-literal language are important in predicting possible RH involvement.

1.2.2 Hemispheric asymmetries for idiom processing

Research investigating the processing of idiomatic expressions in the cerebral hemispheres has produced mixed and conflicting results. Early neuropsychological evidence pointed to the non-dominant RH as the responsible one for the processing of this type of language (Kempler, van Lancker, Marchman and Bates, 1999; Van Lancker and Kempler, 1987). For example, Van Lancker and Kempler (1987) reported that in a picture-matching comprehension task Left Brain Damaged (LBD) patients were more likely than Right Brain Damaged (RBD) patients to preserve comprehension of familiar idiomatic expressions. Additionally, LBD patients were less likely than RBD patients to preserve comprehension of novel sentences. Van Lancker and Kempler (1987) concluded that since LBD patients were more likely to exhibit preserved comprehension skills of familiar idiomatic expressions relative to the RBD group, these phrases are most likely stored and processed differently from novel sentences. However, more recent lesion studies with aphasic patients suggest that it is in fact the LH which governs idioms processing (e.g., Nenonen, Niemi and Laine, 2002; Papagno, Tabossi, Colombo and Zampetti, 2004; for a review of the neuropsychological literature on idiom processing see Papagno, 2010). In addition,

evidence from research relying on other methodologies and recruiting healthy adults also supports the assumption that idioms are processed in the language-dominant LH. For example, during a sentence comprehension task Kana, Murdaugh, Wolfe and Kumar (2012) collected fMRI data from participants who read sentences containing either idiomatic phrases or literal control sentences for which participants had to answer a yes/no comprehension question. The results indicated that sentences containing idiomatic expressions recruited mostly LH regions such as the left temporal cortex, left thalamus and the left inferior frontal gyrus. Kana et al. (2012) concluded that the processing of idiomatic phrases most likely relies on the same neural networks used for processing literal language.

In contrast to both of these assumptions (i.e., idioms are in the realm of the RH or the LH), a representative body of research has recently compiled evidence that processing idiomatic expressions requires a more widely distributed neural network which encompasses both hemispheres. This claim is supported by neuropsychological data (Burgess and Chiarello, 1996; Papagno Curti, Rizzo, Crippa and Colombo, 2006), fMRI data (Romero Lauro, Tettamanti, Cappa and Papagno, 2008), data from a repetitive TMS study (Rizzo, Sandrini, and Papagno, 2007), as well as electrophysiological data (e.g., Proverbio, Crotti, Zani and Adorni, 2009). For instance, in an investigation of the time-course and neural bases of idiomatic language processing, Proverbio et al. (2009) asked participants to read silently sentences ending on an idiomatic expression while the researchers recorded Event Related Potentials (ERPs). Half of the sentences conveyed a literal meaning, whereas the other half primed the idiomatic meaning of the preceding idiom. Participants had to perform a semantic judgement on a target word. The results from the behavioural data showed that responses made to targets after literal sentences were significantly faster than responses made after idiomatic sentences. The electrophysiological data for the N400 component did not show any differences between the sentence types in terms of the latency of the negative deflection. Conversely, the amplitude of the N400 component was much larger for the idiomatic sentences relative to the literal ones suggesting that processing the idiomatic sentences was more effortful. Furthermore, a source analysis of these N400 differences revealed that the neural generators included the left and right occipital lobe, the left and right temporal lobe, the right parahippocampal region, the right middle temporal gyrus and the left middle frontal gyrus. Proverbio et al. (2009) concluded that around 400ms into the processing of idiomatic expressions bilateral brain areas are recruited with larger effects over the right hemisphere. In sum, then, the experimental evidence on idiom processing in the two hemispheres is not in agreement yet as to which

hemisphere is differentially involved in idiomatic processing, even though the most recent evidence points in the direction of bilateral processing.

One reason for such conflicting results could be the fact that idiomatic expressions comprise a large group of non-literal language which is characterised by its multidimensional nature (Canal et al., 2010; Libben and Titone, 2008) which is not always taken into consideration. The current thesis focuses on one variable in particular, namely the degree of idiom decomposition (see Section 1.1.3 above). To our knowledge only one study to date has investigated hemispheric asymmetries and decomposition effects in the time-course of activating idiomatic meanings. Cieslicka (2013) employed a half-field priming paradigm and used sentence-final non-decomposable and decomposable idioms in ambiguous (neutral) and unambiguous (idiomatic) sentence contexts. Decomposable and non-decomposable idioms were matched for ambiguity, familiarity and predictability. The sentences were followed by targets that were either related to the literal meaning or to the idiomatic meaning. In order to investigate different stages in on-line idiom processing, in Experiment 1 the targets followed immediately at the offset of the sentence (ISI: 0ms) while in Experiment 2 there was a delay of 400ms between the offset of the sentence and the presentation of the target (ISI: 400ms). The results from Experiment 1 (ISI: 0ms) indicated that in ambiguous (neutral) contexts, the LH activated only the literal meanings of both decomposable and non-decomposable idioms, whereas the RH activated the literal meanings of decomposable idioms and the idiomatic meanings of non-decomposable idioms. In the unambiguous (idiomatic) contexts the LH activated only the literal meanings of decomposable idioms, while the RH activated the literal meanings and marginally the idiomatic meanings of the non-decomposable idioms. The results from Experiment 2 (ISI: 400ms) showed that in ambiguous (neutral) contexts, the LH activated only the literal meanings of decomposable idioms, whereas the RH activated both literal and idiomatic meanings of these idioms. No activation for either meaning in either hemisphere was found for the non-decomposable idioms. Conversely, in unambiguous (idiomatic) contexts, the LH activated only the literal meanings of both decomposable and non-decomposable idioms, and the RH activated only the literal and idiomatic meanings of the non-decomposable idioms. On the basis of these results, Cieslicka (2013) argues against the predictions of the Decomposition Hypothesis (Gibbs et al., 1989a) according to which non-decomposable idioms should show a processing disadvantage over decomposable ones. On the contrary, in Cieslicka (2013) the idiomatic meanings of non-decomposable idioms became available sooner than the idiomatic meanings of decomposable idioms. The researcher further claimed that these results were modulated by context and hemisphere, with idiomatic meanings of non-decomposable

idioms being activated only in the RH, in both neutral and idiomatic contexts at the 0ms delay, and in idiomatic contexts at the 400ms delay. Cieslicka (2013) concluded that the results indicate that the RH may be more adept at processing non-decomposable idioms, while there is no evidence that the LH may be better at processing decomposable idioms.

1.2.3 Hemispheric asymmetries for lexical ambiguity

In order to investigate the possible differential contributions of each hemisphere during lexical ambiguity resolution, Burgess and Simpson (1988) conducted a series of half-field lexical decision experiments. Participants read centrally presented ambiguous homographs which were followed by laterally presented target words. The targets were either related to the dominant meaning of the ambiguous homograph or to its subordinate meaning. To investigate the time-course of meaning activation in the two hemispheres, Burgess and Simpson (1988) manipulated the delay of presentation of the target stimuli. The investigators used two stimulus onset asynchronies (or, SOAs) - 35ms to explore the early stages of processing, and 750ms to explore the late stages of processing. The results showed that, consistent with an exhaustive access view, at the short SOA both dominant and subordinate meanings were activated in the LH, while at the long SOA the left hemisphere retained only the dominant meanings. On the other hand, at the short SOA only dominant meanings were activated in the RH, while at the long SOA the right hemisphere showed activation for both dominant and subordinate meanings. Burgess and Simpson (1988) argued that the two hemispheres show differential processing for the alternative meanings of ambiguous words that was affected by meaning dominance and the timing of stimulus presentation. In particular, Burgess and Simpson (1988) claimed that subordinate meanings showed a slower rise in the RH which makes them available during the later stages of meaning processing (Burgess and Simpson, 1988; Burgess and Lund, 1998). In a similar vein, Koivisto (1997; 1998) argued that the slower rise of some meanings in the RH might be driven by the possibility that the RH is more adept at relying on post-lexical integration processes.

The hemispheric differences attested in Burgess and Simpson (1988) concerned the study of ambiguous words in isolation. This raises the issue of whether such hemispheric differences hold when ambiguous words are used in context. The results from the literature exploring hemispheric sensitivity to sentential context, however, are varied and inconsistent. On the one hand, some researchers indicate that the RH exhibits little sensitivity to context and meaning which is derived from the syntactic organisation of the sentence (Faust, Babkoff and Kravetz, 1995; Faust, 1998). For example, Faust (1998) reviewed research she had conducted in

previous studies arguing that any priming effects we observe in the RH result from intra-lexical associations between laterally presented target words and words that are used in priming sentences. She suggests that when words from grammatically well-constructed sentences have been scrambled and used as primes only the LH showed priming effects to targets that were related to overall meanings derivable from the scrambled primes. On the other hand, behavioural experiments (Coney and Evans, 2000; Peleg and Eviatar, 2008) and electrophysiological investigations (e.g., Federmeier and Kutas, 1999) provided evidence in support of the claim that the RH is indeed sensitive to sentential context. Lastly, Titone (1998) suggested that there are occasions in which the RH may be even more sensitive to sentential context than the LH. Therefore, even though more recent evidence suggests that the RH is indeed sensitive to contextual meanings, it is still an open question to what extent the RH can derive contextual meanings.

Sense-relatedness effects in the two hemispheres have been attested so far only for ambiguous words presented in isolation. For example, in a priming lexical decision experiment designed to investigate the neural correlates underlying the processing of polysemy and homonymy using EEG, Klepousniotou et al. (2012) report hemispheric asymmetries in the processing patterns for polysemous and homonymous words. In that study participants were presented with prime-target pairs; the primes were the either homonyms (both balanced and unbalanced) or polysemes (both metaphoric and metonymic). With an inter-stimulus interval (or, ISI) of 50ms, the target words were presented for 500ms. The targets were 1) related to the dominant meaning of the prime, 2) related to the subordinate meaning, 3) were unrelated, or 4) not real English words. The results indicated that for homonyms, the dominant meanings showed strong priming effects across both hemispheres, while the subordinate meanings were more primed in the LH. Conversely, for metaphorically motivated polysemous words, subordinate targets showed less priming than the dominant ones but the effects were generally stronger in the RH. In other words, the difference between subordinate and dominant targets was smaller in the RH. For metonymically motivated polysemous words, the dominant and subordinate targets showed equal priming effects which were equally distributed across the two hemispheres. Overall, Klepousniotou et al. (2012) were the first to provide evidence in support of hemispheric differences for processing the alternative meanings of homonymous words and the alternative senses of polysemous words.

1.3 Pun processing studies

Even though puns are considered to be non-literal language, the psycholinguistic literature on pun processing is rather limited (Coulson and Severens, 2007; Goel and Dolan, 2001; Kana and Wadsworth, 2012; Sheridan, Reingold and Daneman, 2009). To the best of our knowledge only these four studies address the two key questions of interest in the present thesis and we will explore them in more detail in the two sections below.

1.3.1 Time-course of double meaning activation

Sheridan et al. (2009) is the only study which bears some relevance for the question of the time-course of double-meaning activation and the implied processing costs during pun comprehension. In an investigation of context effects during the early stages of lexical ambiguity resolution, Sheridan et al. (2009) conducted an experiment to test the predictions of the re-ordered lexical access model (Duffy et al., 1988) and the integration model (Rayner and Frazier, 1989). As discussed in Section 1.1.4 above, according to the re-ordered access model, access to the multiple meanings of ambiguous words is exhaustive and it is governed by two factors, namely influence from the preceding context and lexical information such as meaning dominance. On the other hand, the integration model argues that lexical access may be exhaustive but it is only governed by meaning dominance[1]. Context, however, exerts its influence in a post-access integration stage. Thus, according to the integration model, the dominant meaning is accessed first and if it is compatible with the overall context, integration can then proceed smoothly. If the dominant meaning is incompatible with the context, integration cannot proceed until a subordinate, less frequent meaning has been accessed. In an eye-tracking experiment Sheridan et al. (2009) recorded participants' eye-movements while they read sentences containing biased homographs (i.e., ambiguous words which have at least two meanings and one of them is used more frequently than the other). The homographs were always in mid-sentence position. In the pun condition the context preceding the homograph was consistent with both meanings of the homograph (e.g., '*The lawyer called the tailor to talk about the* ***suit*** *that he filed on his behalf.*') whereas in the single meaning condition, the context preceding the homograph was consistent with the less frequent meaning of the homograph without explicitly ruling out the dominant one (e.g., *'The lawyer called the actor to*

[1]The integration model is similar to the multiple exhaustive access model discussed in Section 1.1.4 in that both models suggest modular access to the mental lexicon, i.e., both models suggest that multiple meanings of ambiguous words are accessed exhaustively. However, the integration model differs from the multiple exhaustive model in that it assumes all meanings are accessed in order of their meaning dominance, while the multiple exhaustive model does not predict meaning dominance effects.

*talk about the **suit** that he filed on his behalf.'*). In both conditions after the neutral context, which consisted of 2-6 words, there was disambiguating context which was always consistent with the subordinate meaning. Sheridan et al. (2009) reported that participants spent significantly longer time reading the ambiguous homograph in the single meaning condition relative to the pun condition because in that condition the preceding context highlighted the less frequent meaning of the homograph leading to competition effects between the dominant and subordinate meanings. Conversely, participants were faster processing the disambiguating context in the single meaning condition because it was consistent with the subordinate meaning and that meaning was already accessed upon reading the homograph. More interestingly, participants spent less time reading the homograph in the pun condition (relative to the single meaning context) presumably because the preceding context was compatible with the dominant meaning of the homograph which participants had accessed first and found compatible. They spent longer in the disambiguating context in the pun condition because it was subordinate-meaning consistent and that meaning had not been accessed upon reading the homograph. Sheridan et al. (2009) concluded that this pattern could only be explained by the re-ordered model which argues that lexical access is an exhaustive process governed from the very early stages both by meaning dominance and contextual effects. The results from this study have implications for the processing costs required for pun comprehension. It forces us to conclude that contexts biasing the two meanings of an ambiguous word might facilitate access to the two meanings, but the same contexts will lead to processing costs when one of the meanings has to be integrated. If this is the case and our studies replicate these findings, the three models on non-literal language processing (namely, the standard pragmatic approach, the direct access and the graded salience hypothesis) will not be able to account for the results as none of them predicts that processing non-literal language could be *easier* than processing the related literal baseline at any stage.

1.3.2 Hemispheric asymmetries for pun comprehension

The rest of the experimental literature on pun processing has addressed the question of possible hemispheric asymmetries for pun comprehension. Even though there is convincing evidence that the RH is involved in processing other types of non-literal language, such as jokes, idioms and lexical ambiguity (see Section 1.2 above), the existing published studies almost unanimously suggest that puns are processed exclusively in the language dominant LH. We speculated though that RH involvement for pun processing may have been obscured in

these studies as they failed to consider the internal semantics of puns and what types of meanings motivated the dual nature of the pun.

For example, Coulson and Severens' (2007) study monitored event-related brain potentials within a half-field semantic priming paradigm. In their study, experimental puns were followed by two related probe words – one was highly related to the pun, while the other was only moderately related. Control puns were followed by unrelated probe words. In order to investigate the time-course of meaning activation during pun processing, the authors observed amplitude modulations time-locked to the probe words in two time windows, namely 300-600ms and 600-900ms post-probe presentation. Coulson and Severens (2007) conducted two experiments. In the first experiment, the aural presentation of puns was immediately followed by the visual presentation of the probe word (ISI: 0ms) tapping onto automatic language processing. In the second experiment, the presentation of the probe word was delayed by 500ms (ISI: 500ms) tapping onto late more attention-driven language processing. In Experiment 1, the results for the 300-600ms time window indicated that in the Left Hemisphere (LH) both related targets exhibited less negative N400 amplitudes relative to unrelated probes. However, in the Right Hemisphere (RH) only the highly related probe words showed a trend for reduced N400 effects relative to the unrelated probes. The results for the 600-900ms time-window (intending to capture the P600 component) indicated that in the LH both related probes elicited more positive amplitudes relative to the unrelated probe, whereas in the RH only the highly related probes elicited more positive amplitudes. Therefore, the authors concluded that during the early stages of pun processing there is a LH advantage for processing puns as only the LH showed processing of both highly related and moderately related probes (the RH processed only the highly related probe words).

In Experiment 2, the results for the 300-600ms time window (to capture N400 effects) indicated that in both hemispheres the highly related and the moderately related probes showed reduced N400 effects. Additionally, the results for the 600-900ms positivity (to capture the P600 effects) suggested that again in both hemispheres the highly related and the moderately related probes showed more pronounced P600 effects. Coulson and Severens (2007) concluded that in the early stages of processing puns did not exhibit hemispheric asymmetries, i.e., both hemispheres processed puns equally well. Thus, the overall pattern of activation obtained from the two experiments of Coulson and Severens' (2007) study suggests that the right hemisphere did not show activation for the moderately related targets in the early stages of processing but their activation rose during the later stage of language

processing. The researchers concluded that the study is consistent with previous results which suggested the slower rise time in the RH for meanings which are less salient (e.g., Simpson and Burgess, 1988). The study also contributed to the existing evidence of the importance of the LH for processing conventional forms of figurative language (e.g., Stringaris, Medford, Giampietro, Brammer and David, 2007). Thus, supporting the main findings from Sheridan et al's (2009) study, Coulson and Severen's (2007) study demonstrated once again that a double-meaning consistent context can facilitate access to the two meanings of the pun (as evidenced by the results for the N400 components) but at the same time can lead to extra processing costs during the integration stages (as evidenced by the results for the P600 component). However, the results for the hemispheric asymmetries are clearly modified by ISI. While the language dominant LH showed processing advantage during automatic processing, the results Coulson and Severens (2007) present indicate bilateral pun processing during the later stages of processing. Even though, the researchers did not highlight this finding in their discussion, we suggest that the lack of hemispheric preferences during the later stages of processing points to some RH involvement during pun processing. We further speculate that such RH involvement might become even more prominent if the internal semantics of the pun is taken into consideration. More generally, and in addition to the lack of control for the internal semantics of the pun, Coulson and Severens's design exhibits a few further flaws, all of which we attempt to rectify in different sections of this thesis. Firstly, from Coulson and Severens's design we cannot draw the definite conclusion that the effects are specifically related to a pun context. In particular, the study lacks an important single-meaning control condition to which we can compare the pun context and extrapolate double-meaning consistent/pun-related effects. To complicate the issue further, even though Coulson and Severens (2007) used an unrelated probe word following their *non*-experimental puns, they did not use an unrelated probe after their experimental puns hence there is no clear baseline condition against which we can compare the activation levels of the two related targets in the experimental pun condition. Therefore, the lack of single-meaning control context together with the lack of unrelated probe words in the experimental pun condition precludes us from relating their findings to effects driven by double-meaning consistent contexts. The same effects could be driven simply by meaning dominance. We address this issue in all of our studies by introducing single-meaning baseline control conditions and unrelated target words that follow all contexts. By introducing these extra levels of controls we can draw firmer conclusions about the potential of the double-meaning consistent context to activate two related meanings simultaneously.

Secondly, Coulson and Severens (2007) used the divided visual field priming paradigm to investigate hemispheric asymmetries during pun processing. This methodology relies on the assumption that if a stimulus is presented briefly to one visual field, it will be initially received and processed by the contralateral hemisphere (Bourne, 2006). However, in order to ensure unilateral presentation, the stimulus presentation should ideally be limited to 150ms, if the task is simple, and it should not be longer than 180ms (ibid.). In their study Coulson and Severens presented their probe words for the duration of 200ms, which is probably long enough to cause the words to be presented bilaterally hence leading to the question of to what extent this design could have induced initial intra-hemispheric processing. We address this issue in the second part of this thesis in which we investigate hemispheric asymmetries during pun processing by choosing to present our target words for the suggested minimum of 150ms. Lastly, Coulson and Severens (2007) chose an ISI of 500ms for their second experiment in which they investigated pun processing during a late stage of language processing. Although strictly speaking this is not a flaw in the design as theirs was the first study that investigated the time-course of meaning activation in puns and hence the researchers had little to guide them in their choice of ISI, we argue that this ISI may not be long enough to show clear RH advantage for pun processing. In the DVF literature on lexical ambiguity resolution clearer RH effects were observed with an ISI of 750ms (e.g., Simpson and Burgess, 1988). Therefore, in the second part of this thesis, which investigates hemispheric asymmetries during pun processing using the DVF methodology, we chose an ISI of 750ms as we thought it is more likely to show clearer RH involvement.

More recently, Kana and Wadsworth (2012) recorded fMRI scans of the brain responses of autistic and healthy control participants during pun comprehension. The experimenters employed an equal number of pun and literal sentences which were matched for length. In the pun sentences the last word was used in a way that evoked two of its potential meanings. The stimuli were arranged in blocks and were presented visually in the scanner. Pun sentences were organised in 4 blocks each containing 6 sentences. Similarly, the literal sentences were organised in 4 blocks of six sentences in each. Each sentence was displayed for 5000ms and there was an inter-stimulus interval of 1000ms between the sentences. The order of blocks was pseudo-randomised but the literal condition was always presented first. Additionally, prior to the presentation of each block, participants were notified what type of sentences to expect (a cue stating “one meaning” was shown before the literal condition and a cue stating “two meanings” was shown before the pun condition). The participants’ task was to read silently each sentence. The data suggest that the autistic participants employed a much more widely

distributed network during language comprehension relative to the normal control participants. More specifically, the autistic group exhibited right hemisphere reliance during language comprehension (relative to the normal control group) that was increased during pun comprehension in particular (relative to literal language comprehension). On the other hand, the results for the normal control participants indicated similar activation patterns for both pun and literal sentences. Moreover, this group displayed significant left hemisphere dominance in the processing of the two types of language relative to right hemisphere recruitment, pointing to the increased involvement of the LH during pun processing. In sum, then, both Coulson and Severens (2007; Experiment 1) and Kana and Wadsworth (2012) provide converging evidence that it is the LH that is predominantly involved in pun processing.

However, a much earlier fMRI study conducted by Goel and Dolan (2001) provide clues that in order to observe some RH involvement for pun processing, we should look closer into the internal motivating structure of the pun. To differentiate between the cognitive and affective processes operating during humour comprehension, Goel and Dolan (2001) tested participants who listened to semantic jokes and phonological jokes; phonological jokes were in fact puns. The researchers argued that while both types of jokes relied on the necessary juxtaposition of mental sets, semantic jokes were motivated by the juxtaposition of semantic sets, whereas puns were motivated by the juxtaposition of phonological sets. For example, *'What do engineers use for birth control?...Their personalities.'* was classified as a semantic joke while *'Why did the golfer wear two sets of pants?...He got a hole in one.'* was classified as a pun. Goel and Dolan (2001) scanned participants while they were listening to the two types of jokes presented in a random order. The researchers asked their participants to listen and judge whether they found the jokes funny or not. Overall, the results indicated that participants took longer to respond to jokes than to non-jokes. Additionally, while all items which were judged as funny showed common activation in the medial ventral prefrontal cortex and bilateral cerebellum, semantic jokes and puns showed differential activation in the two hemispheres. Relative to non-joke baselines, a bilateral pattern of activation in which the right posterior middle temporal gyrus was implicated was revealed only for semantic jokes. Puns, on the other hand, showed differential activation predominantly in the LH, and more specifically the posterior inferior temporal gyrus and the inferior frontal gyrus. These findings have important implications for the studies investigating pun processing in the present thesis as they indicate that semantically motivated puns required bilateral processing, whereas phonologically motivated (or form motivated) puns were exclusively processed in the LH. These findings strongly suggest that the internal structure of the puns is an important factor to be considered

in an investigation of hemispheric processing of puns. It is possible then that one of the reasons the previous two studies reported very little right hemisphere involvement for pun processing was due to the fact that this factor was not taken into consideration.

1.4 Thesis overview

The present thesis, thus, was designed to investigate further the time-course of meaning activation and the hemispheric contributions to pun processing while controlling for the internal structure of the puns. The first experimental chapter (Chapter 2) presents data from a study investigating the early and later stages of pun comprehension by addressing the inter-hemispheric processing of puns motivated by idiomatic expressions. In the following chapter (Chapter 3) we investigate the same questions using puns which are motivated by ambiguous words. In Chapters 4 and 5 we explore the question of the hemispheric preferences for processing puns which are motivated by idioms and ambiguous words respectively. The last experimental chapter (Chapter 6) presents electrophysiological data which provide evidence of the neural mechanisms of pun processing under automatic conditions. In the General Discussion (Chapter 7) we discuss our key findings with reference to contemporary models and hypotheses of inter-hemispheric and intra-hemispheric non-literal language processing.

Chapter 2. Time-course of double meaning activation for puns motivated by idiomatic expressions

2.1 Introduction

Chapter 1 introduced the three leading contemporary models of non-literal language processing, namely *the standard pragmatic approach* (Grice, 1975), *the direct access model* (Gibbs, 1994) and *the graded salience hypothesis* (e.g., Giora, 2012). Both the standard pragmatic approach and the graded salience hypothesis predict processing costs for non-literal language, whereas the direct access model does not predict such costs (for a more detailed discussion of these models refer to Section 1.1). However, the support these models receive comes primarily from investigations which focus on examples of non-literal language which are different from puns. The most widely researched types of non-literal language are *metaphor* (e.g., Arzouan, Goldstein and Faust, 2007a; Arzouan et al., 2007b; Balconi and Amenta, 2010; Coulson and van Petten, 2002; Glucksberg, 2003; Lai et al., 2009; Pynte et al., 1996), *irony* (Colston and Gibbs, 2002; Gibbs, 1994; Giora and Fein, 1999; Pexman, 2008; Regel et al., 2010), *sarcasm* (Briner et al., 2011; Uchiyama, Seki, Kageyama, Koeda et al., 2006), *proverbs* (Ferretti, Schwint and Katz, 2007; Temple and Honeck, 1999), as well as *idioms* (e.g., Gibbs, 1994; Glucksberg, 2001; Holsinger, 2013).

As discussed in Chapter 1, we are aware of only one study to date which might bear some relevance for investigating pun processing, namely that conducted by Sheridan et al. (2009) who tracked participants' eye-movements while they were reading mid-sentence ambiguous homographs embedded in double-meaning consistent or subordinate-meaning consistent contexts (see Section 1.3.1). They conclude that double-meaning consistent contexts facilitated reading the ambiguous homonyms, but at the same time slowed down processing in the disambiguating region after the homonym. This processing pattern does not support any one of the previous models of non-literal language processing as none of them predicts pun-related facilitative effects. We speculated that since the underlying assumption of these models is for non-literal language to have only *one* intended meaning, their main challenge will be to accommodate data from an example of non-literal language which is used to mean at least *two* intended meanings simultaneously. Thus, in order to investigate further pun-related processing costs as well as the role of the underlying semantic structure of the pun in that process, our first experimental chapter focuses on the time-course of double meaning activation for puns which are motivated by the inherent ambiguity between the literal and idiomatic meanings of idiomatic expressions.

Research investigating the time-course of meaning activation for idioms yielded results which could be divided into two main types of models, namely non-compositional and compositional models. Non-compositional models (also known as lexical models) assume that idiomatic meanings are accessed directly from the mental lexicon independently from accessing the literal meanings of the component words of the idiom. For example, according to the lexical representation hypothesis (Swinney and Cutler, 1979) idiomatic and literal meanings of idioms are processed in parallel, but the literal meanings are activated by default and are not instrumental in activating the idiomatic meanings of these idioms. The direct access model (Gibbs, 1994) implies that only the idiomatic meanings of idioms are activated. Both of these models are considered non-compositional as activation of idiomatic meanings is not dependent on preliminary activation of literal meanings. Thus, these models align better with interactive, non-modular models of lexical access (see also section 1.1.3 for a detailed discussion).

On the other hand, investigations which demonstrate that idiom comprehension is a compositional process dependent on a preliminary activation of the literal meanings of idiomatic expressions suggest an alternative approach, according to which idioms are initially processed as free combinations of words (e.g., Boulenger et al., 2009; Cacciari and Tabossi, 1988; Canal et al., 2010; Cutting and Bock, 1997; Holsinger and Kaiser, 2013; Holsinger, 2013; Papagno et al., 2002). According to the compositional approach to idiom processing, idiomatic meanings are likely to be accessed and activated slower than the literal meanings of idioms. Thus, compositional approaches align better with exhaustive, modular models of accessing the mental lexicon (see section 1.1.3 for more details).

One factor which may induce direct access to idiomatic meanings is contextual information. As discussed in Chapter 1, sentential context which biases the literal meaning of idiomatic expressions activates the literal meaning of idioms, which might not be otherwise activated, for example if the sentential context biases more strongly the idiomatic meaning. Since double meaning consistent contexts motivated by the literal and idiomatic meanings of idioms have not been investigated so far we might expect one of two outcomes. On the one hand, given the evidence of a possible parallel activation for the literal and idiomatic meanings of idioms, these contexts might be able to guide access to the two meanings simultaneously without incurring extra processing costs. However, given the evidence that literal meanings are not necessarily activated by default but are an obligatory first step in the processing of idioms, it is

also possible that the double meaning consistent contexts might cause competition effects for the two intended meanings which will imply that these contexts are more taxing to process.

An additional consideration in any context effects we observe is the degree of idiom decomposition. According to the idiom decomposition hypothesis (Gibbs et al., 1989a), idioms are split in three groups according to how decomposable their idiomatic meaning is. In particular, for an idiom to be classed as normally decomposable the literal meanings of its component words should contribute in an obvious way to the overall idiomatic meanings (e.g., *pop the question*→ propose); for an idiom to be classed as abnormally decomposable the literal meanings should be metaphorically related to the overall idiomatic meanings (e.g., *carry a torch for someone*→ have warm feelings for that person); finally, for an idiom to be classed as non-decomposable the literal and idiomatic meanings should be semantically dissimilar (e.g., *kick the bucket* ≠ die). Gibbs et al (1989a) argued that decomposable idioms are processed faster than non-decomposable idioms on account of the similarity between the literal and idiomatic meanings of these idioms. On the other hand, the dissimilarity between the literal and idiomatic meanings of non-decomposable idioms leads to a processing disadvantage. Even though at present the existing experimental literature on idiom decomposition effects cannot give a conclusive answer if and how idiom decomposition affects on-line idiom processing (see section 1.1.3 for a more detailed discussion on idiom decomposition effects), Titone and Connine (1999) provided experimental evidence which demonstrated that only non-decomposable idioms exhibit competition effects between their literal and idiomatic meanings. Titone and Connine (1999) argued that the dissimilarity between the literal and idiomatic meanings of non-decomposable idioms lead to a processing disadvantage for these idioms relative to decomposable idioms. Again, since double meaning consistent contexts rely on the simultaneous processing of the two meanings of these idioms, it is not yet clear what effect, if any, idiom decomposition will play for contexts which intend both meanings equally.

The present study aimed to investigate the time course of double meaning activation in processing puns which were motivated by the inherent ambiguity between the literal and idiomatic meanings of decomposable and non-decomposable idioms (e.g., '*Old skiers never die, they just* ***go downhill****.'* as opposed to '*Old cleaners never die, they just* ***bite the dust.'***). The main goal of the study is to explore if and when the two intended meanings of the pun affect comprehension as well as the role of idiom decomposition in that process. Two cross-modal priming lexical decision experiments were carried out in which participants listened to

sentences ending on an idiomatic expression. In half of the sentences the preceding context primed the idiomatic meanings (single meaning consistent contexts) and in the other half the preceding context primed both the idiomatic meaning and the literal meanings (double meaning consistent punning contexts). Each sentence was followed by the visual presentation of targets which were (i) related to the idiomatic meaning, (ii) related to the literal meaning of an idiom's content word, (iii) unrelated. In Experiment 1, the target words were presented immediately at the end of the sentence (ISI: 0ms) in order to investigate automatic pun processing. In Experiment 2, the presentation of the target words was delayed by 750ms after the end of the sentence to target the later stages of pun processing.

The three processing models of non-literal language make different predictions. In particular, the standard pragmatic approach (Grice, 1975) predicts pun-related processing costs in both experiments. This two-step processing model assumes that sentences will be processed first according to the single meaning consistent context, which is expected to be seen as inadequate or insufficient in the present condition. In a second stage of processing, the idiomatic meanings will be re-analysed according to the meanings of their component words allowing the double meaning consistent context to be processed. Thus, according to this model the pun-related costs in Experiment 1 will reflect difficulties in accessing two simultaneously intended meanings, whereas the pun-related costs in Experiment 2 will reflect difficulties in integrating two simultaneously intended meanings in an overall coherent utterance. The graded salience hypothesis (GSH; Giora, 2003; 2012) would also predict pun-related difficulties in both Experiment 1 and Experiment 2. According to that hypothesis, the double-meaning consistent contexts would lead to competition between lexically coded salient meanings (the idiomatic ones) and the more contextually driven non-salient meanings (the literal meanings). Thus, although for different reasons, both the standard pragmatic approach and the graded salience hypothesis predict processing costs for the double-meaning contexts in both experiments. On the other hand, the direct access model (Gibbs, 1994) would predict no processing differences between single meaning consistent and double meaning consistent contexts as this model assumes that non-literal meanings are processed cost-free.

Guided by previous research (Sheridan et al., 2009), it is expected that relative to single meaning contexts, double meaning consistent puns will be processed faster in Experiment 1 (ISI: 0ms), but they will show processing difficulties in Experiment 2 (ISI: 750ms) implying processing costs due to inability to integrate one intended meaning. It is also expected that idiom decomposition will affect pun processing in a way which will indicate that puns

motivated by decomposable idioms are processed faster than puns motivated by non-decomposable idioms (see also Titone and Connine, 1999). Based on the predictions of the decomposition hypothesis (Gibbs et al., 1989a), we expect that idiom decomposition effects will show a similar trend in single meaning consistent contexts as well, namely decomposable idioms will be processed faster than non-decomposable idioms as the literal meanings of these idioms are related to the overall idiomatic ones in an obvious way.

2.2 Experiment 1

2.2.1 Method

Participants:

Twenty students from the University of Leeds (10 female, mean age=22.35, range=18-34, mean years in education=15.7) participated in the experiment either for course credit or remuneration. All were right-handed (as assessed according to the Handedness Inventory by Briggs and Nebes, 1975), native speakers of English with normal or corrected to normal vision and no history of either neurological or language impairments. The study received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; see Appendix 1(a)).

Design and Materials:

The study had a within-subjects design with three factors: Decomposition, with two levels (decomposable idioms/non-decomposable idioms) specifying the type of idiom; Context, with two levels (single meaning consistent idiomatic/double meaning consistent punning) specifying the type of sentence context; and Target type, with three levels (idiomatically-related, literally-related and unrelated) specifying the type of meaning facilitated in each sentence context (see Table 1). The primary dependent measure was response latencies but accuracy rates were also recorded and analysed.

The materials consisted of 240 sentences in total all varying between 8 and 11 words in length. They were split into two main groups of 120 experimental sentences and 120 non-experimental filler sentences. The experimental sentences consisted of 60 pun sentences and 60 non-pun sentences. The pun-effect in the 60 pun-sentences was rendered possible by the creative use of an idiom in a sentence in which the idiom's idiomatic meaning and the literal reinterpretation of that meaning were both valid and intended meanings. For example, in the sentence *'Old cleaners never die, they just **bite the dust**.'* the idiomatic meaning of 'to bite the dust' meaning 'to die' is accessible to listeners alongside a literal meaning of biting dust which

is foregrounded by the semantic associations between the word 'dust' in the idiom and 'cleaners' in the preceding context. Some of the pun sentences were taken from Internet sites or were adapted from books about jokes (Alexander, 2006; Moger, 1992; http://www.punoftheday.com/cgi-bin/randompun.pl); the rest were especially designed for this experiment following the same underlying principle. In order to ensure that the double-meaning nature of puns was present in all sentences, a simple pen-and-paper questionnaire was designed to consult the expertise of five native speakers of English (see Appendix 2a). All speakers agreed that in all double meaning consistent punning sentences the two meanings of the idiom were clearly equally intended. The 60 non-pun sentences were based on the use of the same idiom in a sentence which did not (explicitly) facilitate the literal reinterpretation. For example, the non-pun sentence for the above idiom was *'Like it or not – we all **bite the dust***.'. In both pun and non-pun sentences, the idiomatic expression appeared in sentence final position.

The 60 idioms on which the experimental stimuli relied were split into two types in order to control for decomposition effects. There were thirty decomposable and thirty non-decomposable idioms. The degree of decomposition of an idiom was assessed on the basis of results obtained from an on-line rating questionnaire. Eight participants, all native speakers of English, read a non-pun sentence which featured the idiom in final position. They had to indicate on a Likert scale (1-7) their intuitions about how much the literal meaning of the individual content words in the idiom contributed to the overall figurative meaning of the idiom in the sentence. On the Likert-scale, 1 indicated that the meanings do not contribute at all to the overall figurative meaning of the idiom while 7 meant that the original meanings of the words are apparent in the meaning of the idiom (see Appendix 3a). The average decomposition value of the decomposable idioms was 4.12 (SD=0.69, range=3-5.86) while the average decomposition value of the non-decomposable idioms was 2.24 (SD=0.63, range=1-3.13). According to Gibbs et al. (1989a) semantic decomposition is not an all-or-nothing issue, but rather it is a matter of degree. Furthermore, critics of the Decomposition Hypothesis argued that studies which found decomposition effects during on-line processing used only a small number of idioms which lie at the extreme ends of the decomposition scale meaning that the effects may be rather specific. Therefore, in the present study we concentrated on idioms which encompass the whole decomposition scale including a very small overlap in the middle, which justifies the use of the median-split method to turn a continuous variable into a categorical one. Nonetheless, a paired-sample t-test conducted on the average decomposition values for the two groups revealed that decomposable idioms had a statistically higher degree

of decomposition than non-decomposable idioms [t(58) = 11.035, p<0.0001, two-tailed, η_p^2 = 0.677]. One may speculate that the literal meanings of non-decomposable idioms such as 'bite the dust' and the literal meanings of decomposable idioms such as 'go downhill' differ in terms of frequency regardless of sentence context as non-decomposable idioms would never really be used literally. If this were the case, then the literal meanings of decomposable idioms will have a higher level of frequency compared to a lower level of frequency for the literal meaning of non-decomposable idioms. To anticipate our results here, we argue the issue of the frequency of the literal meanings of idioms is not something that affects the present results. If this were the case we would expect clear evidence of frequency effects, i.e., faster processing for the literal meanings of decomposable idioms relative to the literal meanings of non-decomposable. This has not been revealed by the data. In particular, in Experiment 2, in which we saw that idiom decomposition interacted significantly with target type, the results indicated that there were no significant differences between the mean reaction times for the literal targets of decomposable idioms and the literal targets of non-decomposable idioms (p=0.163).

An additional on-line questionnaire was designed to assess the idioms' degree of familiarity to control for idiom familiarity effects (see Appendix 3b). Nineteen native speakers of English responded to that questionnaire. They had to read the non-pun sentences and indicate on a Likert-scale (1-7) how familiar they were with each idiom. In that questionnaire 1 indicated not familiar at all and 7 indicated very familiar. The average mean score of familiarity for the decomposable idioms was 4.97 (SD=0.84, range=3.05-6.1) and the average mean familiarity score for the non-decomposable idioms was 4.1 (SD=0.96, range=2.26-5.79) and the difference was found to be significantly different [t(58) = 3.738, p<0.001, η_p^2 = 0.194]. Libben and Titone (2008) argue that decomposition and familiarity are two variables which are highly correlated, i.e., the more decomposable an idiom is, the more familiar it is considered. However, we believe that the correlation between decomposition and familiarity did not affect the results of the current study, as that assumption would lead to the prediction that decomposable idioms are processed faster on account of being more familiar; however, our pattern of results (see Results section below) shows the opposite trend.

All experimental sentences were paired with three target words in such a way that the same target words were used in both the pun sentences and the non-pun sentences. One of the target words was related to the idiomatic meaning of the idiom in the sentence. These target words were seen as synonymous to the figurative expressions and they were selected from an

on-line thesaurus accessed at http://thesaurus.com/. The second type of target was a word related to the literal meaning of one of the content words comprising the idiom. These target words were also chosen from the online thesaurus or sometimes, if possible, from established associative norms (Nelson et al., 1998). The third target word was unrelated to either the idiomatic meaning or the literal one. All target words were matched for familiarity [$F(2,129) = 0.827$, $p = 0.44$] and frequency [$F(2, 177) = 0.19$, $p=0.828$].(http://websites.psychology.uwa.edu.au/school/MRCDatabase/uwa_mrc.htm).

Table 1 **Examples of experimental materials.**

		SENTENCE	TARGET
DECOMPOSABLE IDIOMS	DOUBLE-MEANING/PUN CONTEXT	Old skiers never die, they just ***go downhill***.	**slide**
		Old skiers never die, they just ***go downhill***.	**decline**
		Old skiers never die, they just ***go downhill***.	**soup**
	SINGLE-MEANING/IDIOM CONTEXT	Old painters never die, they just ***go downhill***.	**slide**
		Old painters never die, they just ***go downhill***.	**decline**
		Old painters never die, they just ***go downhill***.	**soup**
NON-DECOMPOSABLE IDIOMS	DOUBLE-MEANING/PUN CONTEXT	Old cleaners never die, they just ***bite the dust.***	**dirt**
		Old cleaners never die, they just ***bite the dust.***	**grave**
		Old cleaners never die, they just ***bite the dust.***	**wire**
	SINGLE-MEANING/IDIOM CONTEXT	Like it or not, we all ***bite the dust***.	**dirt**
		Like it or not, we all ***bite the dust***.	**grave**
		Like it or not, we all ***bite the dust***.	**wire**

The non-experimental filler materials consisted of 120 sentences all of which were between 8 and 11 words long. In order to match the experimental sentences as closely as possible, half of the filler sentences had puns in sentence final position and the other half did not. However, the puns in these sentences were not based on idioms. All filler sentences were followed by non-words. Non-words followed the phonotactics of English but were not real English words. Each filler sentence was matched with 3 different non-words in order for the design to have an equal number of responses for real words and non-words (see Appendix 4 for the full set of materials).

The experimental design used a cross-modal semantic priming paradigm in which priming stimuli were presented aurally and the target stimuli were centrally presented on a computer screen. Auditory materials were read by a female native speaker of English and were recorded using 'Audacity' at 44.1 KHz.

Procedure

The materials were counterbalanced over two lists (List A and List B) and the items in each list were pseudo-randomised so that no three stimuli of the same type occurred consecutively. Participants had to attend two sessions separated by at least a week in order to complete the experiment and were tested individually in both sessions. They were asked to complete one list of stimuli each time. The order of the two lists for the two sessions was also counterbalanced. The presentation of both the aural and visual stimuli and the recording of the reaction times and errors were controlled by E-Prime2. Participants were seated in a comfortable position in front of the computer monitor and they received oral instructions which were reinforced in a written form at the beginning of the experiment. The instructions informed them that they would use headphones to listen to sentences which would be followed by a word presented visually on the computer screen. Participants were asked to listen carefully to each sentence and decide whether the word that appeared on the computer screen at the end of each sentence was a real word in English or not. They had to indicate their decisions by clicking the relevant mouse-buttons as quickly and accurately as possible. The experiment began with a practice block consisting of 11 sentences to allow participants to familiarise themselves with the task. Each trial began with the aural presentation of the priming sentence lasting between 3 and 5 seconds. Immediately at the end of the sentence, with an inter-stimulus interval of 0ms (ISI: 0ms), the target word appeared in the centre of the computer screen. The word remained on the screen for 500ms. Participants were given 1700ms to indicate their lexical decision. As soon as participants responded or at the end of

1700ms if participants failed to indicate any decision, the next trial started automatically after a brief delay of 200ms. The completion of one session consisted of 360 trials split over 2 blocks of 180 trials each. There was a short in-built break of approximately 2 minutes between the two blocks during which participants were instructed to rest their eyes but not leave their seat. Participants were required to return in a week's time to complete the second session of the experiment.

2.2.2 Results

Non-experimental stimuli (all filler sentences followed by non-words) were removed from the analysis. Prior to statistical analyses, errors (4.2%) and outliers (4.7%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Decomposition: decomposable idioms, non-decomposable idioms) x 2(Context: idiom consistent, double-meaning consistent) x 3(Target type: literally-related, idiomatically-related and unrelated) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls (p<.05) post-hoc tests.

Response latencies

The Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiom consistent, double-meaning consistent) x Target type (literally-related, idiomatically-related, unrelated word) ANOVA carried out with reaction time (RT) data revealed only a significant main effect of Target type (by subjects) [*F1*(2,38) = 4.128, MS = 1944, *p*<0.024, η_p^2 = 0.178; *F2*(2,58) = 1.34, MS = 2413, *p*= 0.269, η_p^2 = 0.044] (see Figure 1).

Post-hoc comparisons using the Newman-Keuls test (p <.05) to further explore the significant main effect of Target type revealed that responses to literal targets (527ms) were significantly faster than either the idiomatic targets (534ms, *p*<0.037) or the unrelated ones (536ms, *p*<0.026), while there was no statistical difference between the idiomatic and the unrelated targets (*p*=0.587). Thus, during automatic pun processing, participants found literal meanings easier to process compared to idiomatic and unrelated ones. No other effects reached statistical significance. Mean RTs for all conditions are presented in Table 2.

Table 2 Mean RTs (ms) for all conditions in Experiment 1. Standard deviations are indicated in parentheses.

Decomposition	**Decomposable idioms**		**Non-decomposable idioms**	
Context	**Single-meaning/Idiom**	**Double-meaning/Pun**	**Single-meaning/Idiom**	**Double-meaning/Pun**
Idiomatic Target	530 (61)	542 (71)	537 (72)	530 (72)
Literal Target	526 (66)	522 (72)	536 (67)	527 (67)
Unrelated Target	533 (71)	534 (73)	541 (69)	540 (82)

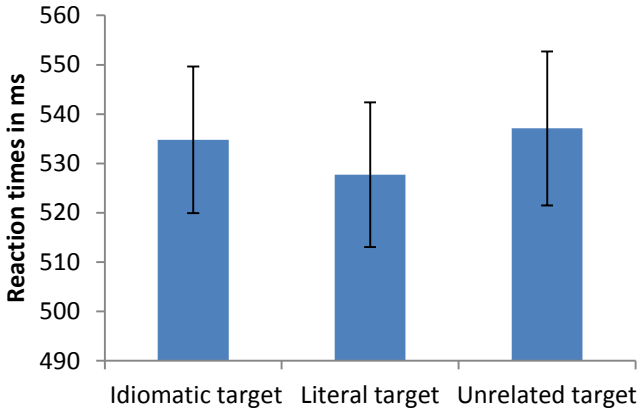

Figure 1 Mean RTs (ms) for the idiomatic, the literal and the unrelated targets. Error bars indicate the standard error of the mean per condition.

Accuracy rates

Similar to the reaction times data, the Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiomatic consistent, double-meaning consistent) x Target type (literally-related, idiomatically-related, unrelated) ANOVA carried out with accuracy (ACC) data revealed only a significant main effect of Target type [*F1* (2,36) = 6.374, MS = 4.162, p<0.004, η_p^2 = 0.262; *F2*(2,58) = 4.225, MS = 3.719, p<0.019, η_p^2 = 0.127]. No other significant effects were found.

The Newman-Kuels post-hoc test (p<0.05) revealed that participants made significantly fewer mistakes for idiomatic targets (1.09%) in comparison to unrelated targets (1.46%, p<0.008). In addition, significantly fewer mistakes were made to literal targets (1.02%) in comparison to unrelated targets (p<0.006), while literal and idiomatic targets did not differ from each other (p=0.619). Thus, unlike the reaction times data, the accuracy data shows that both idiomatic

and literal meanings of idioms were activated. The percentage of errors for all conditions is presented in Table 3.

Table 3 Percentage of errors for all conditions in Experiment 1.

Decomposition	**Decomposable idioms**		**Non-decomposable idioms**	
Context	**Single-meaning/Idiom**	**Double-meaning/Pun**	**Single-meaning/Idiom**	**Double-meaning/Pun**
Idiomatic Target	1.16%	1.32%	0.95%	0.95%
Literal Target	1.05%	0.58%	1.16%	1.32%
Unrelated Target	1.37%	1.68%	1.16%	1.63%

2.2.3 Discussion

The results of Experiment 1 provide evidence in support of compositional models of idiom processing which point to the importance and early activation of the literal meanings of idioms. Additionally, the lack of priming effects for the idiomatic targets in the latency data speaks to the possible slow rise time of idiomatic meanings during idiom processing. However, the results from the accuracy data suggest that idiomatic meanings may have been activated during the very early stages of idiom processing. This discrepancy between the reaction times data and the accuracy data requires further investigation employing more sensitive designs and methodologies. Crucially, however, consistent with the predictions of the direct access model at the early stages of pun processing participants did not seem to be processing double meaning consistent contexts in a different way to processing the single meaning consistent contexts. The lack of processing differences between the two types of context during the short ISI could be due to the uncertain status of the activation levels of the idiomatic meanings (i.e., evidence of activation in accuracy data but not in RT data). Since the pun effect relies on the literal re-interpretation of idiomatic meanings, it can only be achieved after these meanings have been activated. Therefore, in order to test the possibility that the pun effect will arise after the idiomatic meanings show robust priming effects, in Experiment 2 we increased the inter-stimulus interval between the sentence primes and the word targets to 750ms which taps onto the later stages of processing during which we expect to see more stable activation levels for idiomatic meanings.

2.3 Experiment 2

2.3.1 Method

Participants: Participants who took part in Experiment 1 also participated in Experiment 2. The experiment received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Materials and Design: Experiment 2 used the same materials and design as Experiment 1.

Procedure: The procedure was also the same as in Experiment 1 apart from the fact that the target word appeared on the screen with a delay of 750ms after the end of the priming sentence in order to investigate the time course of meaning integration during pun processing. As discussed in the Introduction, one possible reason why Coulson and Severens (2007) did not observe clear RH involvement for pun processing was that they chose an ISI of 500ms, which may not have been long enough for such involvement to occur. Therefore, in order to be able to tie our results better with the DVF literature on lexical ambiguity resolution, which more consistently found RH involvement with an ISI of 750ms, we chose a delay of 750ms. However, in order to be consistent within the bounds of the present thesis we also used the same ISI of 750ms for the experiments that rely on the semantic priming paradigm with central presentation of targets. Hence all experiments in the present thesis that investigate the later stages of pun processing will use an ISI of 750ms.

2.3.2 Results

As in Experiment 1, non-experimental stimuli (all filler sentences followed by non-words) were removed from the analyses. Prior to statistical analyses, errors (4.4%) and outliers (4.3%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Decomposition: decomposable idioms, non-decomposable idioms) x 2(Context: idiom consistent, double-meaning consistent) x 3(Target type: literally-related, idiomatically-related and unrelated) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls ($p<.05$) post-hoc tests.

Response latencies

The Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiom consistent, double-meaning consistent) x Target type (literally-related, idiomatically-related,

unrelated) repeated measures ANOVA carried out with reaction time (RT) data revealed a significant main effect of Target type, [*F1*(2,38) = 14.811, MS = 6734, *p*<0.001, η_p^2 = 0.438; *F2*(2,58) = 6.50, MS = 10694, *p*<0.003, η_p^2 = 0.183]. The results also indicated a significant main effect of Context, [*F1*(1,19) = 5.256, MS=2091, *p*<0.033, η_p^2 = 0.217; *F2*(1,29) = 4.74, MS = 2487, *p*<0.038, η_p^2 = 0.140] as well as a two-way Decomposition x Target type interaction which reached significance by subjects [*F*1(2,38) = 5.33, MS = 1838, *p*<0.01, η_p^2 = 0.219] but not items [*F2*(2,58) = 1.48, MS = 3211, *p*=0.236 η_p^2 = 0.049].

Post-hoc comparisons using the Newman-Keuls test (p <.05) to further explore the significant main effect of Target type revealed that there were differences between all types of targets. The literal targets (528ms) were again responded to faster than both the idiomatic (537ms; *p*<0.007) and the unrelated targets (546ms; *p* <0.001). In addition, idiomatic targets were also significantly faster than unrelated targets (*p*<0.01) indicating that after a delay of 750ms idiomatic meanings reached strong activation levels. Post-hoc tests to further explore the significant effect of Context revealed that double-meaning punning sentences (534ms) were processed faster than single meaning consistent sentences (540ms, *p*<0.033) (see Figure2).

Finally, the post-hoc tests to further explore the significant Decomposition x Target type interaction showed different patterns for decomposable and non-decomposable idioms. For non-decomposable idioms, both literal targets (531ms) and idiomatic targets (531ms) showed robust priming effects relative to unrelated targets (545ms, *p*<0.003 and *p*<0.006 respectively). In contrast, for decomposable idioms, the responses to the literal targets (523ms) showed strong priming effects relative to the unrelated targets (545ms, *p*<0.0002) whereas the idiomatic targets (542ms) did not differ from unrelated targets (545ms, *p*=0.723) (see Figure3). Thus, these findings suggest that in this time window, the idiomatic meanings of non-decomposable idioms were processed in parallel with their literal meanings, while only the literal meanings of decomposable idioms were facilitated. Even though the three-way interaction of Decomposition x Context x Target Type did not reach significant levels, a closer look at the data revealed a numerical trend for some priming effects for the idiomatic meanings of decomposable idioms in the double-meaning consistent punning context. In particular, the mean response time for the idiomatic targets of decomposable idioms in the double-meaning consistent context was 536ms, whereas the mean response times for the same targets in the single-meaning consistent context was 549ms. We explore the importance

of this observation in the general discussion section below. Mean RTs for all conditions are presented in Table 4.

Table 4 Mean RTs (ms) for all conditions in Experiment 2. Standard deviations are indicated in parentheses.

Decomposition	**Decomposable idioms**		**Non-decomposable idioms**	
Context	**Single-meaning/Idiom**	**Double-meaning/Pun**	**Single-meaning/Idiom**	**Double-meaning/Pun**
Idiomatic Target	549 (65)	536 (61)	536 (70)	526 (70)
Literal Target	525 (76)	522 (76)	530 (68)	532 (70)
Unrelated Target	547 (73)	545 (70)	551 (77)	541 (66)

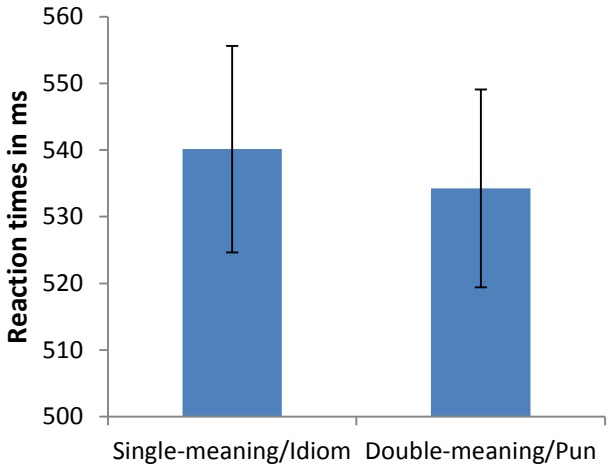

Figure 2 Mean RTs (ms) for single meaning idiomatic contexts and double-meaning punning contexts. Error bars indicate the standard error of the mean per condition.

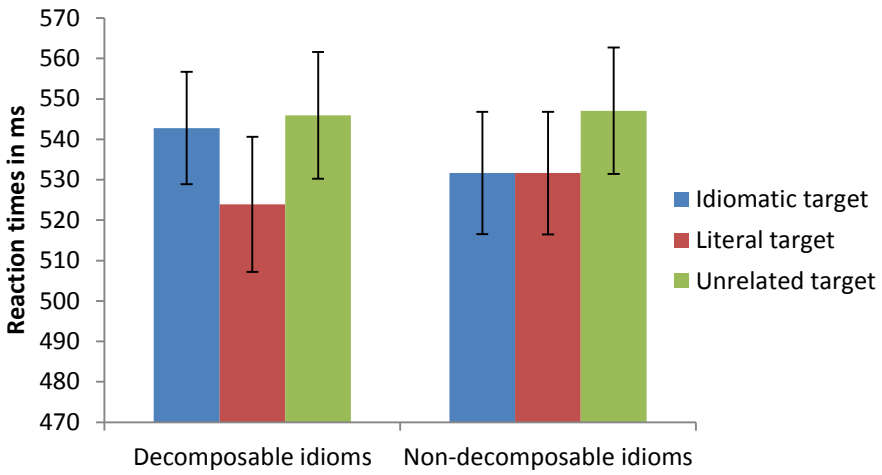

Figure 3 Mean RTs (ms) for the idiomatic, the literal and the unrelated targets for decomposable and non-decomposable idioms. Error bars indicate the standard error of the mean.

Accuracy rates

The Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiom consistent, double-meaning consistent) x Target type (literally-related, idiomatically-related, unrelated) ANOVA carried out with accuracy (ACC) data revealed only a significant two-way interaction of Decomposition x Context [*F1*(1,19) = 6.125, MS = 8.817, p<0.022, η_p^2 = 0.244; *F2*(1,29) = 6.134, MS = 5.878, p<0.019, η_p^2 = 0.175]. However, Newman-Keuls post-hoc tests (p<0.05) did not reveal any further significant effects. The percentage of errors for all conditions is presented in Table 5.

Table 5 Percentage of errors for all conditions in Experiment 2.

Decomposition	**Decomposable idioms**		**Non-decomposable idioms**	
Context	**Single-meaning/Idiom**	**Double-meaning/Pun**	**Single-meaning/Idiom**	**Double-meaning/Pun**
Idiomatic Target	1.35%	0.80%	0.85%	1.35%
Literal Target	1.05%	1.20%	1.45%	1.70%
Unrelated Target	1.65%	1.45%	0.95%	1.90%

2.3.3 Discussion

The overall pattern of results that emerged from Experiment 2 suggests that during the later stages of pun processing double meaning consistent punning contexts behave differently from related single meaning contexts. More specifically, as evidenced by the shorter reaction times to punning contexts, the results indicate that the double-meaning consistent sentences were easier to process than single-meaning consistent sentences. Furthermore, inconsistent with the predictions of the Decomposition hypothesis, the data suggest that non-decomposable idioms were processed faster than decomposable ones. Our pattern of results, however, is in accord with previous investigations of decomposition effects which also did not find experimental support for the predictions of the Decomposition hypothesis (e.g., Cieslicka, 2013). In particular, our results showed that at a delay of 750ms both idiomatic and literal meanings of non-decomposable idioms showed priming effects while the idiomatic meanings of the decomposable idioms were treated as unrelated to the prime.

2.4 General Discussion

The study presented in this chapter aimed to investigate the time-course of double meaning activation for pun processing as well as the effects of idiom decomposition in that process. According to the idiom decomposition hypothesis (Gibbs et al., 1989a) non-decomposable idioms are harder to process relative to decomposable idioms as the default de-compositional process during idiom comprehension fails to operate for non-decomposable idioms. In order to explore the time course of double meaning consistent contexts motivated by decomposable and non-decomposable idioms we conducted two lexical decision experiments in which participants listened to sentence-final idioms in an idiomatic context (single meaning consistent) or a punning context (double-meaning consistent). The results indicate that firstly, in contrast to the predictions of the Decomposition Hypothesis, it was the decomposable idioms which showed a processing disadvantage in single meaning consistent contexts, and secondly, the double-meaning consistent punning contexts (irrespective of decomposition effects) were processed faster than the single-meaning consistent contexts implying that puns were less taxing to process relative to the baseline.

Idiom processing and the Decomposition Hypothesis

According to the Decomposition hypothesis (Gibbs et al., 1989a), decomposable idioms are processed faster than non-decomposable ones due to a perceived similarity between the literal meanings of the idioms' components and their overall idiomatic meanings. Conversely, the lack of such similarity between the literal and idiomatic meanings of non-decomposable idioms leads to a processing disadvantage. Based on these tenets of the Decomposition hypothesis, we expected that decomposable idioms would show a processing advantage over non-decomposable idioms. However, the data did not support this prediction. Instead, the present findings are consistent with experimental evidence which points to the assumption that decomposable idioms could be harder to process than non-decomposable idioms (Cieslicka, 2013; Zhang et al, 2013). Additionally, the data have clear implications for idiom representation consistent with the hybrid representation hypothesis (Cutting and Bock, 1997) which argues that the idiomatic meanings of idioms are accessed via the literal meanings of the idioms' component words.

The data revealed that in single-meaning contexts it was only the idiomatic meanings of non-decomposable idioms which showed some activation during the later stages of processing, whereas the idiomatic meanings of decomposable idioms were treated as unrelated. Although such evidence is not consistent with the predictions of the Decomposition Hypothesis (Gibbs et al., 1989), it is not entirely unexpected. To be more specific, based on theoretical evidence that idioms' analysability and flexibility can be explained by their internal semantics, Gibbs et al (1989a) *initially* predicted that decomposable idioms would take *longer* to process as their idiomatic meanings would rely on meaning computation rather than meaning retrieval. However, experimental results showed the opposite pattern, namely that non-decomposable idioms took longer to process than decomposable ones. Thus, Gibbs and his colleagues suggested that non-decomposable idioms took longer to process because the default mechanism for processing all idioms is decomposition which failed to work with non-decomposable idioms. Since finding decomposition effects during on-line processing of idioms is a difficult task in itself (Libben and Titone, 2008), the assumption that decomposable idioms were easier to process than non-decomposable ones has been left largely unchallenged so far. However, experimental evidence that decomposable idioms could potentially be harder to process has already been observed in recent investigations of idiom processing (Cieslicka, 2013; Zhang et al, 2013). Such results are in line with the ones obtained in our study. For example, in a half-field semantic priming study, Cieslicka (2013) reported that the idiomatic

meanings of non-decomposable idioms were activated sooner than the idiomatic meanings of decomposable idioms. In particular, the researcher found evidence that at a short ISI (0ms) only the idiomatic meanings of non-decomposable idioms were activated. Thus, it is conceivable that the advantage for decomposable idioms found by Gibbs and colleagues could be seen as a task-related effect. In particular, Gibbs et al (1989a) used a phrase verification task in which participants were shown strings of words and were instructed to decide as quickly and accurately as possible whether the string formed a meaningful phrase in English or not. Such a task is unlikely to tap into the more immediate on-line processing underlining idiom comprehension. Additionally, there is little evidence that it was the idiomatic meaning of these phrases that motivated participants' performance. The reasoning for this assumption is based on evidence drawn from the literature on ambiguity resolution. In that line of research, a processing advantage is often observed for ambiguous words whose different senses are related to each other while a similar advantage is not observed for ambiguous words whose meanings are totally unrelated (e.g., Klepousniotou and Baum, 2007). Moreover, such advantage is observed mostly in designs that test ambiguous words in isolation and the participants' task is to perform a lexical decision on a related target word. However, Rodd et al. (2002) argue that the ambiguity advantage for the related senses may only emerge because the lexical decision task does not require a specific meaning to be activated implying that a lexical decision could be performed successfully irrespective of what exact semantic information has been activated. Similarly, the phrase verification task Gibbs et al (1989a) used with idioms in isolation may have had similar effects. It is not clear what motivated participants' performance so it could easily be assumed that participants may have performed the task on the basis of the literal readings of idioms only. Therefore, the processing advantage Gibbs et al. observed for decomposable idioms could disappear if these idioms were used in sentences which require the activation of the idiomatic meanings only. Overall, our claim is that although decomposable idioms may show some processing advantage over non-decomposable idioms if they are processed in isolation and with a task which does not require a specific meaning to be activated, such processing advantage would disappear if idioms are employed in sentences which prime their idiomatic meanings.

Furthermore, one might speculate that the advantage we found for non-decomposable idioms over decomposable ones might be specific only to this late stage of idiom processing. In particular, in Experiment 1 we employed an ISI of 0ms and the results failed to show activation for the idiomatic meaning of either decomposable or non-decomposable idioms. Such results are consistent with the slow rise of idiomatic meanings proposed by Cacciari and Tabossi (e.g.,

Cacciari and Tabossi, 1988). In Experiment 2 we employed an ISI of 750ms which taps a relatively late stage of processing. Thus, our study cannot provide evidence for the activation levels of idiomatic meanings during intermediary stages, i.e., between 0 and 750ms. Given the findings reported in Caillies and Butcher (2007) indicating a faster rise of idiomatic meanings for decomposable idioms, i.e., the idiomatic meanings of decomposable idioms were activated at an ISI of 350ms, whereas the idiomatic meanings of non-decomposable idioms showed activation only at a delay of 500ms, one might speculate further that due to the close similarity between the idiomatic and literal meanings of decomposable idioms the idiomatic meanings are actually less stable and less fixed. Thus, their activations may rise and decay a lot faster than the idiomatic meanings of non-decomposable idioms. However, we argue that this is an unlikely scenario for the following reason. Recall from the Results section that a numerical trend for some priming of the idiomatic meanings of decomposable idioms was observed for the double-meaning consistent punning contexts. The implication of this finding is that priming is observed for these meanings in the pun context because both idiomatic and literal meanings are required for understanding the pun. On the other hand, the close similarity between literal and idiomatic meanings of decomposable idioms precludes the activation of the idiomatic meanings in single-meaning consistent context because the intended idiomatic meaning is probably realised though the semantically related literal meaning (see Holsinger, 2013 for a similar interpretation of idiomatic meanings being realised through the literal meanings of the idiom's component words). Furthermore, the literature on lexical ambiguity resolution offers a very similar understanding for the activation of the subordinate senses of polysemous ambiguous words (Klepousniotou et al., 2008). More specifically, it is argued that due to the close semantic similarity between the dominant and subordinate senses of polysemous words there is a possibility for the subordinate senses to be realised through the dominant ones (ibid.). Therefore, we argue that the possibility of an early activation of the idiomatic meanings of decomposable idioms which fades at a later processing stage is unlikely to be the case. It is more likely to assume that these meanings will only be activated by contexts which explicitly prime both literal and idiomatic meanings, i.e., the double-meaning consistent punning contexts.

Thus, our data strongly points to the possibility that during later processing stages, decomposable idioms are harder to process than non-decomposable ones when the preceding sentential context primes their idiomatic meanings. Our data further suggest that decomposable and non-decomposable idioms probably follow qualitatively different processing mechanisms, namely a serial mechanism of processing for decomposable idioms

and a parallel mechanism of processing for non-decomposable idioms. To be more specific, during the processing of both types of idioms, literal meanings were accessed at the short ISI and remained active during the stage of processing in which contextually irrelevant meanings do not normally show priming effects (i.e., during the late stages of processing). Furthermore, for both types of idioms the rise of the idiomatic meaning was relatively late in the process of idiom comprehension. Therefore, consistent with compositional models of idioms processing (e.g., Holsinger, 2013) we conclude that the activation of the literal meanings of idioms is an important aspect in the processing of idiom comprehension. We further argue that the processing disadvantage for decomposable idioms is explained by the serial mechanism for activating these idiomatic meanings. In other words, activating decomposable idiomatic meanings follows an inferential mechanism whereby literal meanings are processed before the related idiomatic meanings, whereas activating non-decomposable idiomatic meanings relies on meaning access and retrieval. In particular, during the later stage of processing there is a lack of priming effects for the idiomatic meanings of decomposable idioms and strong priming effects for their literal meanings (relative to the baseline unrelated meanings), whereas literal and idiomatic meanings of non-decomposable idioms show strong priming effects of similar magnitude relative to the unrelated targets. In sum, we conclude that the processing of non-decomposable idioms follows a parallel mechanism of meaning activation that is consistent with lexical models of idiom processing (e.g.., the lexical representation hypothesis, Swinney and Cutler, 1979) whereas the processing of decomposable idioms follows a different pattern that is more consistent with compositional models of idiom processing (e.g., Holsinger, 2013; Holsinger and Keiser, 2013; Cacciari and Tabossi, 1988). Ultimately, the results we obtained from the current study have implications for the argument that decomposable and non-decomposable idioms are represented differently in mental space. The faster processing of the idiomatic meaning of non-decomposable idioms is driven by a process of meaning retrieval in a similar way to retrieving single words' meanings, whereas the slower processing of the idiomatic meanings of decomposable idioms is driven by a process of composition in a similar way to processing inferences thus only non-decomposable idioms have a separate mental representation (Caillies and Butcher, 2007; Titone and Connine, 1999).

Context effects: Implications for puns and cognitive effort

The ultimate point of interest in the current study was the processing costs associated with the simultaneous processing of the literal and idiomatic meanings of decomposable and non-decomposable idioms in double-meaning consistent (pun) sentences. Even though,

decomposition effects were evident only in single-meaning consistent contexts, the results revealed that puns do not seem to incur extra processing costs. Indeed, in Experiment 2 they show a processing advantage over single-meaning idiomatic contexts. This pattern of results is neither consistent with previous research (Sheridan et al., 2009) nor with the predictions of any of the models on non-literal language processing.

In particular, both the response latency and the accuracy data from Experiment 1 (ISI: 0ms) indicate that puns go largely unnoticed by the intact brain during lexical access as responses after double meaning consistent contexts were almost identical to responses after single-meaning consistent contexts. Such findings do not replicate the processing advantage for puns attested by Sheridan et al. (2009) at the early stages of processing. However, this discrepancy is easily explained by the different choice of materials and design in the two studies. To be more specific, in an eye-tracking experiment Sheridan et al. (2009) employed biased homographs in mid-sentence position in such a way that in non-pun single meaning sentences, context preceding the homograph primed the *secondary* meaning of that homograph, while in pun sentences the preceding context was compatible both with the *primary and subordinate* meanings. The disambiguating context in the two conditions was consistent with the subordinate meaning of the homograph. For example, for a homograph such as 'suit' the pair of experimental sentences was as follows, '*The lawyer called the tailor to talk about the* ***suit*** *that he filed on his behalf.'* – dual meaning and, *'The lawyer called the actor to talk about the* ***suit*** *that he filed on his behalf.'* – single meaning. Therefore, the processing advantage found for the pun context in the homograph region could be attributed to the initial access of the primary meaning, which is activated by default and it was also compatible with the context preceding the homograph. Contrastingly, Sheridan et al. (2009) reported a processing disadvantage for the pun condition during the disambiguating context that was subordinate meaning consistent. The disadvantage could have been caused by the fact that the subordinate meaning was not active at that stage and it had to be accessed. Thus, it is likely that the two meanings of the homograph were not accessed in the homograph region and processing the double meaning punning sentence may have proceeded as processing a single meaning consistent sentence biasing a dominant meaning of a homograph. We argue that based on this assumption implications about ease of processing associated with pun processing during the early stages of lexical access are harder to make.

Furthermore, the pun was operationalized in this study as the effect that is achieved by the re-analysis of the idiomatic meaning of an idiom as the sum total of the meanings of the idiom's

components. Therefore, in order for the double-meaning nature of the pun to be noticed we need evidence that both the literal and idiomatic meanings were activated. There was little evidence from our data to suggest that during automatic processing the idiomatic meanings were activated. We argue that if the idiomatic meaning was not accessed at the short ISI (0ms), then logically no re-interpretation of that meaning could be detected. In sum, both Sheridan et al. (2009) and our study suggest that initially possibly only one meaning is selected for later processes of meaning integration, namely the primary meaning of a biased homograph in Sheridan et al's investigation and the literal meanings of the idioms in our study (which are considered the primary ones by compositional models of idiom processing). Therefore, we conclude that during short ISIs processing double meaning consistent sentences based on the re-interpretation of idiomatic expressions proceeds in a manner similar to processing single meaning idiomatic contexts. Alternatively, behavioural responses may not be sensitive enough to indicate decomposition effects and context effects under automatic processing necessitating more sensitive methodologies to investigate these effects (see Chapter 6 that discusses electrophysiological data gathered during processing these puns under automatic processing revealing both decomposition effects and context effects).

However, the results from Experiment 2 (ISI: 750ms) showed that during the later stages of processing double-meaning consistent punning contexts were processed significantly faster than single-meaning consistent contexts implying that they are less taxing for the language processor. Once again, such findings are in opposition to the relative difficulty attested for pun processing during the later stage of processing in Sheridan et al. (2009). This discrepancy can also be attributed to differences in design and methodology. In Sheridan et al's case, the disambiguating context after the ambiguous homograph was consistent with the subordinate meaning, which in the punning contexts, lead to necessary re-analysis. On the other hand, in the present study the punning effect is observed in sentence final position without the possibility of further disambiguation. The pun in our case has the effect of a punch line that leaves the listener in limbo. Therefore, one possible way to explain the observed processing advantage for puns in Experiment 2 is to suggest that once all the relevant meanings have been activated, they formed a richer and more closely interconnected network of meanings. An example taken from our materials could illustrate this. We have a pair of sentences such as '*The* ***pupils*** ***gave the late-comer the cold shoulder***.' vs. '*The* ***cannibals*** ***gave the late-comer the cold shoulder***'. From Experiment 2, we know that in both sentences the underlined sections primed both the literal and the idiomatic meanings of the idioms, but responses to the second sentence were significantly faster. We argue that this could be explained by the additional

semantic relation imposed on the second sentence by the use of the word 'cannibal' rather than 'pupil'. Only when the word 'cannibal' is used do we have a situation in which the idiomatic and the literal meanings of the combination 'give someone a cold shoulder' are equally relevant. In this punning context, we either have a case where the two meanings are effortlessly integrated in two different schemata, which is not seen as incurring additional processing costs, or alternatively the obviously explicit double nature of puns in a way neutralizes the process of integration. We believe that the second explanation is more likely to be in the present data set. To be more specific, the reaction times after single-meaning contexts in Experiment 2 were longer than those for the same condition in Experiment 1, whereas the reaction times after the double meaning consistent puns are identical in the two experiments suggesting that perhaps an integration process is bypassed in this situation. Further support for this line of reasoning comes from the fact that puns are considered a figure of speech that characterises light and playful communication, rather than a tool for imparting knowledge and obtaining information. Therefore, pun comprehension might be seen as relying on higher level top-down processing (especially during the later stages of processing in which participants were given extra processing time). The influence of such global factors may in this case be seen as facilitating comprehension because a lower level process of semantic integration may have been bypassed but still the higher level of pragmatic processing has been carried out. These assumptions are in accordance with interactive models of language processing that argue that lower level semantic processing maybe carried out simultaneously with pragmatic, global context processing and these two processes continually influence each other (Hagoort and Van Berkum, 2007; Hagoort, Hald, Bastiaansen and Petersson, 2004; Jackendoff, 2002; Nieuwland and Van Berkum, 2006).

2.5 Conclusions

In summary, the present study found support for the claim that puns are not necessarily more cognitively taxing for the language processor. In particular, it seems that people tend to notice puns based on idiomatic expressions only during the later stages of processing when puns are processed faster than their related non-punning language. Thus, we argue that pun processing may be governed by more global top-down processing mechanisms. Our results are inconsistent with the traditional two-step models of language processing during which a first pass processing occurs at sentence level, while a second pass processing integrates the sentence meaning into a more global discourse meaning. To a large extent the present findings are more consistent with interactive, one-step, models of language processing and

comprehension, even though they are not consistent with the predictions of the direct access model that does not predict processing differences between single meaning consistent and double-meaning consistent language. Furthermore, the results lend support to current compositional models of idiom processing. They speak to the fact that the literal meanings of the idioms' component words are obligatorily activated and maintained active for the entire time-course of meaning activation during online idiom processing. Additionally, we present evidence that points to the slower time rise of idiomatic meanings and the importance of the degree of decomposition in that process. In particular, a higher degree of decomposition results in serial activation of idiomatic meanings akin to inferential processing, i.e., the idiomatic meanings are activated on the basis of an extension of the literal meanings of the idioms' component words. On the other hand, the literal and idiomatic meanings of non-decomposable idioms are activated in parallel, i.e., the idiomatic meanings of these idioms are dissimilar to their literal meanings thus their activation relies on meaning retrieval as they have a separate mental representation. Overall, then, the study argues that processing double-meaning consistent contexts is to a very large extent bound to the mechanisms required for processing the underlying language that motivates the multiplicity of puns. In order to investigate further whether the processing advantage of double-meaning consistent contexts is borne out of the processing peculiarities of the internal structure of the expressions/lexical items that motivate the pun (i.e., idioms in the current study) we designed a second study in which the double meaning consistent context exploited the inherent multiplicity of ambiguous words.

Chapter 3. Time-course of double meaning activation for puns motivated by lexical ambiguity

3.1 Introduction

The previous chapter provided experimental evidence which showed that processing the dual nature of puns is not necessarily more taxing relative to processing language consistent with a single meaning. Indeed the data demonstrated that processing puns might even be easier than processing single meaning language during later stages of processing. The current chapter continues to investigate the time-course of double meaning activation and the role of the internal semantics of the pun by focusing on double meaning consistent puns that are motivated by the multiple meanings of ambiguous words.

As discussed in Chapter 1 (Section 1.1.4) research on lexical ambiguity resolution yielded results that support one of three models of lexical access, namely the multiple exhaustive access model (Swinney, 1979), the selective access model (Simpson, 1981) and the re-ordered exhaustive access model (Duffy et al., 1988; Hogaboam and Perfetti, 1975). According to the multiple exhaustive access model all meanings of an ambiguous word are accessed exhaustively irrespective of contextual bias, whereas the selective access model suggests that contextual clues guide access only to the contextually appropriate meaning. Finally, according to the re-ordered accessed model, multiple meanings are accessed exhaustively but in order of their meaning dominance, i.e., their frequency of usage in language.

As further discussed in Section 1.1.4, the strength of contextual bias is an important factor that might induce selective access. According to Duffy et al. (1988), experiments in which the ambiguous word is preceded by neutral context generally favour an exhaustive access, while results obtained from experiments in which the ambiguous word is preceded by disambiguating context are less clear as they might favour either exhaustive access, if the disambiguating context is not strong enough, or selective access, if the disambiguating context strongly biases the intended meaning. Simpson and Krueger (1991) reported data that supported this claim. In particular, they found that neutral non-biasing contexts resulted in exhaustive access to all meanings of the ambiguous words, whereas strongly biasing contexts activated only one meaning irrespective of the inter-stimulus interval between prime and target. In order to reconcile these two extremes, the re-ordered accessed model respects early context effects, but at the same time suggests that access to multiple meanings is exhaustive in order of meaning dominance. Since double meaning consistent contexts rely on the

simultaneous bias towards dominant and subordinate meanings of ambiguous words, we might expect one of two outcomes. On the one hand, given the evidence of multiple exhaustive access to all meanings of ambiguous words irrespective of contextual bias, we might expect that these contexts could guide access to the two meanings simultaneously without incurring extra processing costs. In contrast, if we assume either a selective access or re-ordered access, it is also possible that the double meaning consistent contexts might cause competition effects for the two intended meanings which will imply that these contexts are more taxing than single meaning consistent contexts to process.

An additional consideration in any context effects we observe is the sense-relatedness issue that concerns ambiguous words. According to arguments developed within theoretical linguistics (e.g., Cruse, 1986), which also received experimental support (e.g., Klepousniotou, 2002), ambiguous words are subdivided into homonymous (whose dominant and subordinate meanings are unrelated to each other) and polysemous (whose dominant and subordinate senses are related to each other). For example, '*bank*' is a homonymous word as the meaning of 'financial institution' is unrelated to that of a 'long strip of land along a river'. Alternatively, '*mouth*' is a polysemous word as its dominant sense referring to 'a cavity in the lower part of the human face' and the subordinate one of 'an opening of a cave' are related (on the basis of metaphoric extension). The experimental literature on sense-relatedness effects demonstrates that the similarity between the dominant and subordinate senses of polysemous words speeds up the recognition of these ambiguous words only, whereas the effect is not observed for homonymous ambiguous words whose dominant and subordinate meanings are unrelated (e.g., Klepousniotou and Baum, 2007). Even though there is convincing evidence that sense-relatedness effects are present for processing ambiguous words in isolation, there is still not enough evidence to suggest that they also play a role for ambiguous words when they are used in sentential context (see Section 1.1.4 for a more detailed discussion on sense-relatedness effects). To the best of our knowledge, the present study is the second one to investigate sense-relatedness effects for ambiguous words used in context (Klepousniotou et al (2005b) first investigated this question and did not report sense-relatedness effects in sentential contexts).

The present study aimed to investigate the time course of double meaning activation in processing puns that are motivated by the inherent ambiguity between the dominant and subordinate meanings/senses of homonymous and polysemous ambiguous words (e.g., *'You pay your psychiatrist with a sanity **check**'* as opposed to ***'**The prince with a bad tooth got a*

crown'). The main goal of this study is to explore whether and how the two equally intended meanings of the pun affect comprehension as well as what role sense-relatedness plays in that process. Two cross-modal priming lexical decision experiments were designed in which participants listened to sentences that ended in an ambiguous word when it was (1) used in its dominant meaning (dominant-meaning consistent sentences), (2) used in its subordinate meaning (subordinate-meaning consistent sentences), or (3) used in a double-meaning consistent way, (or puns). Each sentence was followed by the visual presentation of targets that were (i) related to the dominant meaning of the ambiguous words (dominant targets), (ii) the subordinate meaning of the ambiguous words (subordinate targets) or (iii) were unrelated targets. In Experiment 3, the target words were presented immediately at the end of the sentence (ISI: 0ms) in order to investigate automatic pun processing. In Experiment 4, the presentation of the target words was delayed by 750ms after the end of the sentence to target the late stages of pun processing.

According to the standard pragmatic approach we would expect to see pun-related processing costs in both experiments. This two-step processing model assumes that sentences will be processed first according to the dominant meanings/senses of ambiguous words. In a second stage of the processing, all meanings/senses will have to be simultaneously integrated. Thus, the pun-related costs in Experiment 3 will be seen to reflect difficulties in accessing two simultaneously intended meanings that differ in terms of meaning dominance, whereas the pun-related costs in Experiment 4 will reflect difficulties in integrating two simultaneously intended meanings in an overall coherent utterance. Similarly, according to the graded salience hypothesis, the pun-related processing costs are likely to be evident in both experiments. As far as Experiment 3 is concerned, if according to Giora (2012) both context and meaning dominance operate independently during meaning access, we would expect the pun-related processing cost to be evident only when we compare double-meaning consistent sentences to dominant-consistent sentences. In particular, the pun-related difficulty in this case will be a direct result from the punning context that tries to access two simultaneously intended meanings in the same time window irrespective of meaning dominance. As far as Experiment 4 is concerned, we would expect general pun-related processing costs that will be a result from difficulties integrating two simultaneously intended meanings/senses. In contrast, consistent with the predictions of the direct access model (Gibbs, 1994) there will be no evidence of pun-related processing costs in either of the two Experiments. This one-step processing model predicts that intended non-literal meanings are processed cost-free.

Finally, if sense-relatedness effects influence lexical ambiguity resolution in sentence context in a similar way they influence ambiguity resolution for words in isolation, we would expect to see processing advantages for polysemous ambiguous words over homonymous words in all three context types, namely dominant consistent, subordinate consistent and double-meaning consistent (or, puns).

3.2 Experiment 3

3.2.1 Method

Participants:

Twenty native speakers of English (10 male) with an average age of 25 years (range 19-34) and an average of 14.8 years of education (range 13-17) took part in the experiment for remuneration. All participants were right-handed, as assessed according to the Handedness Inventory by Briggs and Nebes (1975), with normal or corrected to normal vision and no history of either neurological or language impairments. The experiment received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Design and Materials:

The study had a within-subjects design with three factors: Context, with three levels (dominant consistent, subordinate consistent, and double-meaning consistent), specifying the type of biasing sentence context; Lexical Ambiguity, with two levels (homonymy and polysemy), specifying the type of ambiguous word biased in each context; and Target type, with three levels (dominant target, subordinate target and unrelated target) specifying the type of meaning facilitated in each sentence context (see Table 6). The primary dependent measure was response latencies but accuracy rates were also recorded and analysed.

The materials consisted of 360 sentences in total varying between 8 and 11 words in length. They were split into two main groups of 180 experimental materials and 180 non-experimental fillers. The experimental sentences consisted of 60 pun sentences (double-meaning consistent sentences) and 120 non-pun sentences (60 dominant-meaning consistent + 60 subordinate-meaning consistent sentences). The pun effect in the 60 pun sentences was rendered possible by making explicit the inherently ambiguous nature of words that have more than one meaning. For example, in the sentence *'The prince with a bad tooth got a **crown**.'* the ambiguous word 'crown' is used in such a way that at least two of its meanings – the one denoting a head ornament and also the part of a tooth or its substitute – are accessible to

listeners at the same time. Some of the pun sentences were taken from Internet sites, or were adapted from books about jokes (Alexander, 2006; Moger, 1992; http://www.punoftheday.com/cgi-bin/randompun.pl); the rest were especially designed for this experiment following the same underlying principle. In order to ensure that the double-meaning nature of puns was present in all sentences a simple pen-and-paper questionnaire was designed to consult the expertise of five native speakers of English (see Appendix 2b). All speakers agreed that in all double meaning consistent punning sentences the two meanings of the ambiguous word were clearly equally intended. The non-pun sentences were based on the use of the same ambiguous word in such a way that each pun sentence was paired with two non-pun sentences. In one of them the ambiguous word was used in a context biasing its dominant meaning, while in the second the same word was used again but in a context biasing its subordinate meaning. For example, the two non-pun sentences to match the abovementioned pun were, '*When Elizabeth became a queen she got a **crown'***. (dominant-meaning consistent sentence), and '*The NHS charges three hundred pounds for a **crown**.'* (subordinate-meaning consistent sentence). In all three types of sentences the ambiguous word appeared in sentence final position.

The sixty ambiguous words were split into two groups in order to control for sense-relatedness effects during ambiguity processing. There were thirty homonymous words and thirty polysemous words. The majority of the homonyms (70%) were biased in that one of their meanings was more frequent than the other; also, the majority of the polysemous words (75%) were metaphorically polysemous in that the subordinate sense was related to the dominant one on the basis of a metaphorical extension. Even though half of those sixty words were previously used in investigations on lexical ambiguity (Klepousniotou et al., 2012), for the purposes of the current study the degree of sense-relatedness of all sixty words was assessed again on the basis of results obtained from an on-line rating questionnaire (see Appendix 5a). Fourteen participants, all native speakers of English, read the non-pun sentences presented in pairs. They had to indicate on a Likert scale from 1 to 7 their intuitions about how much the different meanings/senses facilitated in each sentence are related to each other. For example, '*When Elizabeth became a queen she got a **crown**'* and '*The NHS charges three hundred pounds for a **crown**.'* formed a pair and participants had to decide to what extent the meaning of head ornament and the part of a tooth are related to each other. On the Likert scale, 1 indicated that the meanings are not related at all, while 7 indicated that the senses are highly related. Homonyms received a mean relatedness value of 1.278 (SD: 0.263; range=0.929-1.929) that was significantly lower than the mean relatedness value of 3.567 for polysemous words (SD:

1.303; range = 2.071-6.214) [t(31.368)=9.424, p<0.001 (two-tailed)]. Moreover, an additional on-line questionnaire was designed in order to assess which one of the two meanings is the dominant one and which one is the subordinate (see Appendix 5b). Nine participants, all native speakers of English, responded to that questionnaire. They had to read the same pairs of sentences and indicate on a Likert scale from 1 to 7 how familiar they were with each of the two meanings. In this questionnaire 1 indicated not familiar at all and 7 indicated very familiar. The mean familiarity score for the dominant meanings of homonyms was 5.87 (SD: 0.874, range = 2.667-6.889) and the mean familiarity score for the subordinate meanings of those words was 3.807 (SD: 1.116, range = 1.444-5.778) [t(29) = 8.783, p<0.001 (2-tailed)]. Similarly, the mean familiarity score for the dominant senses of polysemous words was 5.718 (SD: 0.865, range = 3.00-6.889) and the mean familiarity score for the subordinate senses of polysemous words was 3.885 (SD: 1.070, range = 1.333-5.333). The mean familiarity scores for the dominant meanings of the two groups did not vary significantly from each other [t(58) = 0.676, p=0.502)]. Similarly, the mean familiarity score for the subordinate meanings of the two groups did not vary significantly from each other either [(t(58) = 0.275, p=0.784)]. Finally, the two groups of ambiguous words, namely the homonyms and the polysemes, were controlled for written frequency [(t(55) = 0.915, p=0.364 (2-tailed)], familiarity [t(42)=-0.992, p=0.327)], concreteness [t(41) = -1.214, p=0.232 (2-tailed)] and imageability [t(41)=-1.550, p=0.129 (2-tailed)].

The experimental sentences were paired with three target words in such a way that the same target words were used for the three sentence types, namely the dominant-meaning consistent, the subordinate-meaning consistent and the double-meaning consistent. One of the target words was related to the dominant meaning of the ambiguous word, the second target was related to the subordinate meaning and the third target was unrelated in meaning. All target words, including those that were borrowed from previous experiments on lexical ambiguity (Klepousniotou et al., 2012) were chosen from established associative norms (Nelson et al., 1989). All targets were matched for imageability [F(2,73.362) = 2.480, p=0.091] and familiarity [F(2,171) = 0.054, p=0.948] (see Table 6 for examples of the experimental stimuli).

Table 6 Example of experimental materials.

		SENTENCE	TARGET
HOMONYMY	**DOUBLE-MEANING/PUN CONTEXT**	A cross-eyed teacher can't control his ***pupils***.	**student**
		A cross-eyed teacher can't control his ***pupils***.	**eyelid**
		A cross-eyed teacher can't control his ***pupils***.	**hotel**
	DOMINANT CONTEXT	After he retired he only teaches private ***pupils.***	**student**
		After he retired he only teaches private ***pupils.***	**eyelid**
		After he retired he only teaches private ***pupils.***	**hotel**
	SUBORDINATE CONTEXT	These drops are necessary to dilate your ***pupils.***	**student**
		These drops are necessary to dilate your ***pupils.***	**eyelid**
		These drops are necessary to dilate your ***pupils.***	**hotel**
POLYSEMY	**DOUBLE-MEANING/PUN CONTEXT**	The prince with a bad tooth got a ***crown***.	**throne**
		The prince with a bad tooth got a ***crown***.	**dentist**
		The prince with a bad tooth got a ***crown***.	**whisper**
	DOMINANT CONTEXT	When Elizabeth became a queen she got a ***crown***.	**throne**
		When Elizabeth became a queen she got a ***crown***.	**dentist**
		When Elizabeth became a queen she got a ***crown***.	**whisper**
	SUBORDINATE CONTEXT	The NHS charges three hundred pounds for a ***crown***.	**throne**
		The NHS charges three hundred pounds for a ***crown***.	**dentist**
		The NHS charges three hundred pounds for a ***crown***.	**whisper**

The non-experimental filler materials consisted of 180 sentences that were between 8 and 11 words long. In order to match the experimental materials as closely as possible, 60 of the filler sentences had puns in sentence final position while the rest did not. All filler sentences were followed by non-words that observed the phonotactics of English but were not real English words. Each filler sentence was matched with 3 different non-words in order for the design to match the experimental materials as closely as possible and have an equal number of responses for real words and non-words (see Appendix 6 for the entire set of stimuli).

The experimental design used a cross-modal semantic priming paradigm in which priming stimuli were presented aurally and the target stimuli were centrally presented on a computer screen. Auditory materials were read by a female native speaker of English and were recorded using 'Audacity' at 44.1 KHz.

Procedure:

The materials were counterbalanced over four lists (List A1, A2, B1 and B2) and the items in each list were pseudo-randomised so that no three stimuli of the same type occurred consecutively. Participants had to attend two sessions separated by at least a week in order to complete the experiment and were tested individually in each session. Each session lasted approximately 55 minutes and participants were asked to complete two lists of stimuli each time. The order of the two lists for the two sessions was also counterbalanced. The presentation of both the aural and visual stimuli and the recording of the reaction times and errors were controlled by E-Prime2. Participants were seated in a comfortable position in front of the computer monitor and they received oral instructions that were reinforced in a written form at the beginning of the experiment. The instructions informed them that they would use headphones to listen to sentences that would be followed by a word presented visually on the computer screen. Participants were asked to listen carefully to each sentence and decide whether the word that appeared on the computer screen is a real word in English or not. They had to indicate their decisions by clicking the relevant mouse-buttons as quickly and accurately as possible. The experiment began with a practice block consisting of 11 sentences to allow participants to familiarize themselves with the task. Each trial began with the aural presentation of the priming sentence, which lasted between 3 and 5 seconds. Immediately at the end of the sentence, with an inter-stimulus interval of 0ms (ISI: 0ms), the target word appeared in the centre of the computer screen. The word remained on the screen for 500ms. Participants were given 1700ms to indicate their lexical decisions. As soon as participants responded or at the end of 1700ms if they failed to indicate any decision, the next trial started

automatically after a brief delay of 200ms. The completion of one session consisted of 540 trials spread over the two lists. Half way through each list there was a short in-built break during which participants were instructed to rest their eyes but not leave their seat. At the end of the first list there was a longer break of approximately 10 minutes during which participants could leave their seat and the experimenter prepared the next list. Participants were required to return in a week's time to complete the second session of the experiment, which followed the exact same procedure as the first session. The second session also incorporated 540 trials, which resulted in 1080 trials overall for the entire experiment.

3.2.2 Results

Non-experimental stimuli (all filler sentences followed by non-words) were removed from the analyses. Prior to statistical analyses, errors (3.62%) and outliers (4.41%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Lexical Ambiguity: homonymy, polysemy) x 3(Context: dominant-consistent, subordinate-consistent, double-meaning consistent) x 3(Target type: dominant-related, subordinate-related and unrelated) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls ($p<.05$) post-hoc tests.

Response latencies

The Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) ANOVA carried out with reaction time (RT) data revealed significant main effects of Context (for subjects), [*F1*(2,38) = 3.606, MS = 1017, *p*<0.037, η_p^2 = 0.160; *F2*(2,58) = 1.61, MS = 1382, *p*=0.209, η_p^2 = 0.053] and Target type, [*F1*(2,38) = 24.538, MS = 11489, *p*<0.001, η_p^2=0.564*; F2*(2,58) = 10.39, MS = 19741, *p*<0.001, η_p^2 =0.274]. The two-way interaction of Lexical Ambiguity and Context also reached significant levels, [*F1*(2,38) = 8.668, MS = 1958, *p*<0.001, η_p^2 = 0.313*; F2*(2,58) = 3.65, MS = 3601, *p*<0.032, η_p^2 = 0.112]. Moreover, the two-way interaction between Lexical Ambiguity and Target type reached significant levels (for subjects) [*F1*(2,38) = 9.508, MS = 3324, *p*<0.0004, η_p^2 =0.334; *F2*(2,58) = 1.59, MS = 6564, *p*=0.213, η_p^2 =0.052].

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant main effect of Context revealed that reaction times for double-meaning consistent sentences (519ms) were significantly slower relative to dominant-meaning consistent sentences (513ms, p<0.031); the difference between double-meaning consistent and subordinate-meaning consistent sentences (515ms) did not reach significant levels (p=0.097); the difference in reaction time between dominant-meaning consistent sentences and subordinate-meaning consistent sentences was also not significant (p=0.350). This pattern of results suggests that the double-meaning consistent context exerts influence at the very early stages of language processing, which is consistent with interactive models of processing. Additionally, Newman-Keuls post-hoc comparisons to further explore the significant main effect of Target type revealed that reaction times for both dominant targets (509ms) and subordinate targets (511ms) were significantly faster relative to the unrelated target (527ms, in both cases p<0.0001). Consistent with the multiple exhaustive access model the results do not show statistically significant differences between the reaction times for dominant and subordinate targets.

Furthermore, post-hoc comparisons to explore further the significant two-way interaction of Lexical Ambiguity and Context revealed the following patterns. For homonymy, there were no significant differences in the reaction times for the dominant-meaning consistent (517ms), subordinate meaning consistent (516ms) and double-meaning consistent sentences (515ms). For polysemy, the reaction times for both dominant-meaning consistent (509ms) and subordinate meaning consistent sentences (514ms) were significantly faster than double-meaning consistent sentences (523ms; p<0.003 and p<0.02 respectively), while dominant and subordinate sentences did not differ from each other (p=0.08). Lastly, the results also indicated that the reaction times for homonymous double-meaning consistent sentences (515ms) were significantly faster than polysemous double-meaning consistent sentences (523ms, p<0.025). Indeed the results indicate that polysemous puns were the slowest/hardest to process suggesting that, when required to create a contradictory context as in puns, processing two unrelated meanings might be less taxing than processing two very closely related senses (see Figure 4).

Lastly, the Newman-Keuls tests for post-hoc comparisons exploring further the significant interaction of Lexical Ambiguity and Target type showed that the reaction times for both dominant targets (503ms) and subordinate targets (517ms) of polysemous words were significantly faster than unrelated targets (526ms, in both cases p<0.01). Moreover, consistent

with the re-ordered access to the mental lexicon, the reaction times for the dominant targets were significantly faster than the reaction times for the subordinate targets of these words. A different pattern was observed for the reaction times of homonymous words; both dominant (514ms) and subordinate targets (506ms) were significantly faster than unrelated targets (528ms, $p<0.001$). Surprisingly, however, subordinate targets were significantly faster than dominant targets as well. The overall pattern of results for the two types of ambiguity suggests that sense-relatedness effects are observed during automatic processing even in conditions in which the ambiguous words are employed in sentential contexts (see Figure 5). Mean reaction times for all conditions are presented in Table 7.

Table 7 Mean RTs (ms) for all conditions in Experiment 3. Standard deviations are indicated in parentheses.

Lexical Ambiguity	**Homonymy**			**Polysemy**		
Context	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**
Dominant Target	512 (69)	522 (69)	511 (64)	492 (62)	505 (69)	515 (78)
Subordinate Target	508 (63)	504 (69)	510 (74)	517 (65)	514 (68)	524 (67)
Unrelated Target	533 (68)	527 (75)	526 (72)	521 (72)	526 (65)	533 (74)

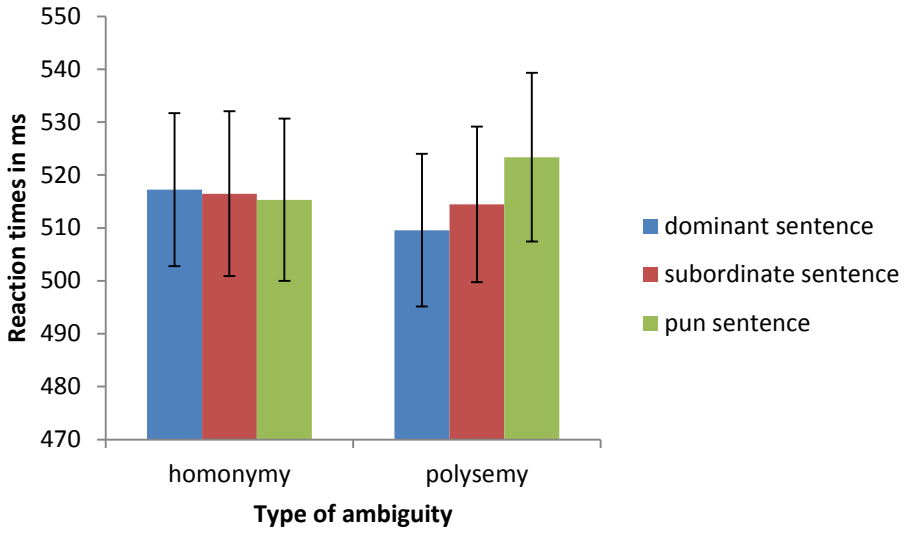

Figure 4 Mean RTs (ms) for homonymy and polysemy in the three types of sentences, dominant consistent, subordinate consistent and double-meaning consistent sentences (i.e., puns). Error bars indicate the standard error of the mean per condition.

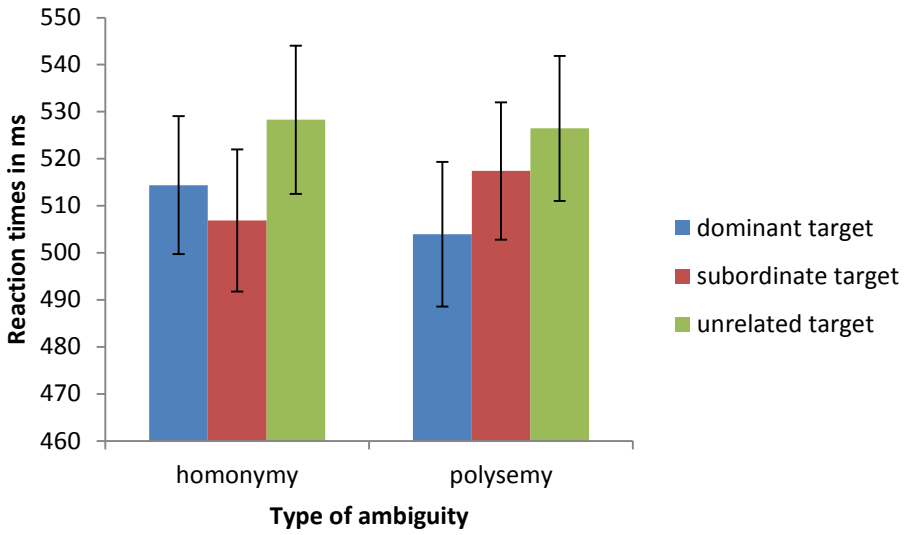

Figure 5 Mean RTs (ms) for the dominant related, subordinate related and unrelated targets following either homonymy or polysemy. Error bars indicate the standard error of the mean per condition.

Accuracy rates:

The Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) ANOVA carried out with accuracy (ACC) data revealed a significant main effect of Target type [*F1*(2,38) = 30.136, MS = 35.436, *p*<0.001, η_p^2 =0 .613; *F2*(2,58) = 10.524, MS = 23.624, *p*<0.001, η_p^2 =0.266]. Furthermore, the results showed a significant interaction of Lexical Ambiguity and Target type (for subjects), [*F1*(2,38) = 8.351, MS = 8.108, *p*<0.001, η_p^2 = 0.305; *F2*(2,58) = 2.996, MS = 5.406, *p* =0.058, η_p^2 =0.094].

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant main effect of Target type revealed that there were significantly fewer errors both for dominant targets (0.67%) and subordinate targets (0.89%) relative to unrelated targets (1.7%, *p*<0.0001 in both cases). There were no statistically significant differences between the error rates for the dominant and subordinate targets (*p*=0.116).

Post-hoc pair-wise comparisons with Newman-Keuls test (p<.05) to explore further the significant interaction of Lexical Ambiguity and Target type revealed two patterns. Firstly, the error rates for both dominant (0.88%) and subordinate targets (0.67%) for homonymous words were significantly lower relative to unrelated targets (1.93%; *p*<0.0001 in both cases). Interestingly, mirroring the reaction times data there were fewer errors for the subordinate

targets than for the dominant ones, even though this difference did not reach significant levels in the accuracy data. Secondly, the error rates for the dominant targets of polysemous words (0.45%) were significantly lower than both the subordinate targets (1.12%) and the unrelated targets (1.47%, $p<0.01$ in both cases). There was a very strong tendency for the subordinate targets to result in fewer errors relative to the unrelated targets but the difference was only a trend ($p=0.059$). The percentage of errors for all conditions is presented in Table 8.

Table 8 Percentage of errors for all conditions in Experiment 3.

Lexical Ambiguity	**Homonymy**			**Polysemy**		
Context	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**
Dominant Target	0.95%	1.10%	0.60%	0.40%	0.55%	0.40%
Subordinate Target	0.70%	0.55%	0.75%	1.25%	1.15%	0.95%
Unrelated Target	2.10%	2.05%	1.65%	1.35%	1.55%	1.50%

3.2.3 Discussion

The overall pattern of results in Experiment 3 indicates that double-meaning consistent sentences require longer processing time compared to dominant-meaning consistent sentences, whereas the processing time for subordinate-meaning consistent sentences does not differ significantly either from the dominant-meaning-consistent or the double-meaning consistent sentences. Such results are consistent with the graded salience hypothesis that argues that during the initial stages of meaning access both contextual effects and salience effects will be observed. Additionally, the results suggest that sense-relatedness effects lead to differential access to the mental lexicon. In particular, even though for both homonymous and polysemous ambiguous words all meaning/senses are activated, there is convincing evidence that only polysemous words follow a re-ordered exhaustive access since their dominant senses were accessed significantly faster relative to their subordinate senses. Interestingly, the dominant meanings of homonymous words, while clearly showing robust priming effects relative to the unrelated condition, were significantly slower than the subordinate meanings for those words. Furthermore, sense-relatedness effects were seen to affect differentially the double-meaning consistent sentences, namely polysemous double-meaning consistent sentences required considerably longer processing times relative to the homonymous double-

meaning consistent sentences. In order to investigate to what extent these effects are confined to the initial stages of meaning access we designed a second experiment that tapped on to later stages of language processing. In Experiment 4, the target word was presented for a lexical decision with a delay long enough to ensure a transfer to a qualitatively different type of language processing (ISI: 750ms). Consistent with the predictions of the graded salience hypothesis we expected evidence for continued contextual effects of the double-meaning consistent sentences.

3.3 Experiment 4

3.3.1 Method

Participants:

Twenty native speakers of English (10 male) with an average age of 25.1 years (range 18-37) and an average of 16.25 years of education (range 13-22) took part in the experiment for remuneration. All participants were right-handed, as assessed according to the Handedness Inventory by Briggs and Nebes (1975), with normal or corrected to normal vision and no history of either neurological or language impairments. The experiment received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Materials design - Experiment 4 used the same materials and design as Experiment 3.

Procedure - The procedure was also the same as in Experiment 3 apart from the fact that the target word appeared on the screen with a delay of 750ms (ISI: 750ms) after the end of the priming sentence in order to investigate the time course of meaning activation in pun processing during the later stages of language processing.

3.3.2 Results

As in Experiment 3, non-experimental stimuli (all filler sentences followed by non-words) were removed from the analyses. Additionally, the data from one participant was removed as an outlier; standard deviations for this participant for some conditions reached 280ms (while overall mean standard deviation for this experiment was 131ms, range = 51-140ms). Prior to statistical analyses, errors (4.4%) and outliers (4.78%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Lexical Ambiguity: homonymy, polysemy) x 3(Context: dominant-consistent, subordinate-consistent, double-meaning consistent) x 3(Target type: dominant-related, subordinate-related and

unrelated) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls (p<.05) post-hoc tests.

Response latencies:

The Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) ANOVA carried out with reaction time (RT) data revealed a significant main effect of Target type, [*F1*(2,36) = 20.5207, MS = 10517, *p*<0.001, η_p^2 = 0.533; *F2*(2,58) = 9.89, MS = 18 289, *p*<0.001, η_p^2 = 0.254]. Additionally, the results showed significant interactions of Lexical Ambiguity and Target type (for subjects), [*F1*(2,36) = 5.153, MS = 2 361, *p*<0.011, η_p^2 = 0.223; *F2*(2,58) = 1.12, MS = 4565, *p*=0.334, η_p^2=0.037], and Context and Target type (for subject), [*F1*(4,72) = 2.434, MS = 810, *p*<0.05, η_p^2=0 .119; *F2*(4, 116) = 1.38, MS = 1295, *p*=0.246, η_p^2 = 0.045].

Post-hoc comparison tests (Newman-Keuls, p=.05) to explore further the main effects of Target type showed that the responses to the dominant targets (552ms) were significantly faster than the responses to the unrelated targets (571ms, *p*<0.001). In contrast, response times to subordinate targets (565ms) were marginally faster than the responses to the unrelated targets (571ms, p=0.069). Therefore, the results suggest that subordinate meanings, which showed similar priming effects to dominant targets during the automatic stage of processing in Experiment 3, might have decayed.

Moreover, the Newman-Keuls post-hoc tests to explore further the significant interaction of Lexical Ambiguity and Target type revealed that reaction times for both dominant (555ms) and subordinate targets (560ms) for homonymous words were significantly faster than unrelated words (572ms; *p*<0.001 and *p*<0.01 respectively) while there were no significant differences between dominant and subordinate targets. For polysemous words, only the reaction times for the dominant targets (549ms) were significantly faster than the unrelated targets (569ms, *p*<0.001), while subordinate targets (571ms) did not differ from unrelated targets (*p*=0.708) (See Figure 6).

Finally, post-hoc comparison tests (Newman-Keuls, p=.05) to explore further the significant interaction of Context and Target type showed the following patterns for the three different

sentence types. In dominant-meaning consistent sentences, dominant targets (552ms) were significantly faster than unrelated targets (568ms, $p<0.002$) while subordinate targets (572ms) were not statistically different from unrelated targets ($p=0.66$). In subordinate-meaning consistent sentences, both dominant (552ms) and subordinate (562ms) targets were significantly faster than unrelated targets (575ms; $p<0.0001$ and $p<0.02$ respectively). Finally, in double-meaning consistent sentences, only dominant targets (552ms) were significantly faster than unrelated targets (569ms; $p<0.002$) while subordinate (562ms) and unrelated targets were not statistically different from each other ($p=0.22$). Thus, in the late stages of processing there is evidence for selective access in dominant biasing sentences, while subordinate biasing sentences induce exhaustive access to alternative meanings. Furthermore, double-meaning consistent sentences behave in a similar way to dominant-meaning consistent ones (see Figure 7). Mean RTs for all conditions are presented in Table 9.

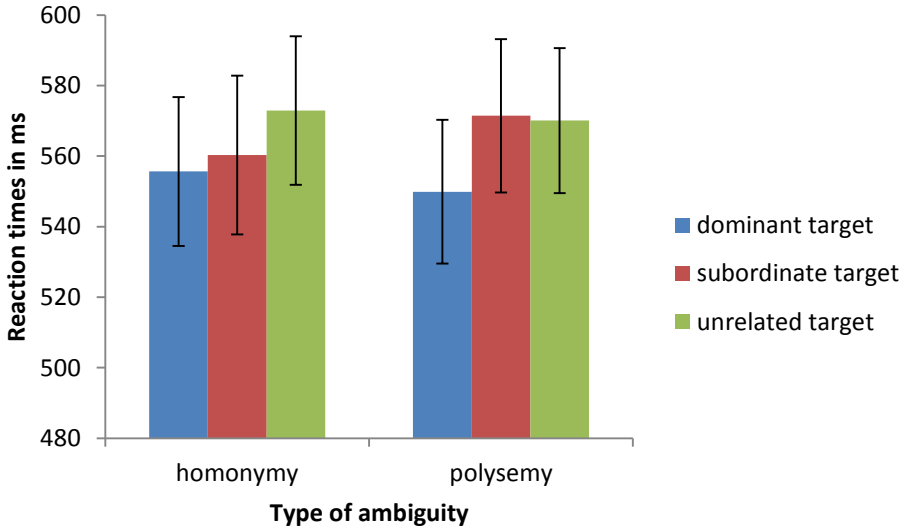

Figure 6 Mean RTs (ms) for the dominant related, subordinate related and unrelated targets following either homonymy or polysemy. Error bars indicate the standard error of the mean per condition.

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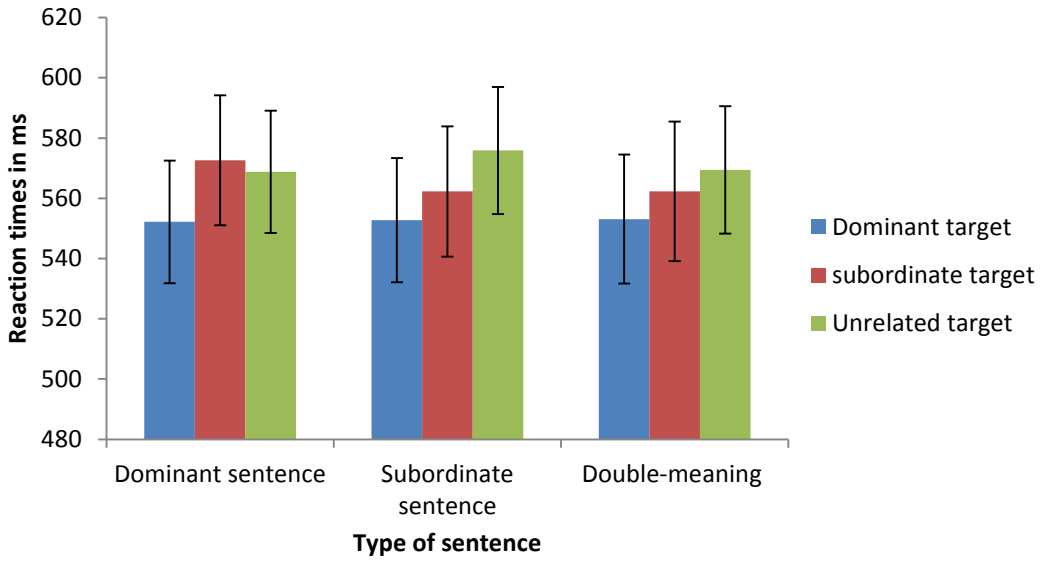

Figure 7 Mean RTs (ms) for the dominant-related, subordinate-related and unrelated targets following dominant, subordinate and double-meaning consistent contexts. The error bars indicate the standard error of the mean per condition.

Table 9 Mean RTs (ms) for all conditions in Experiment 4. Standard deviations are indicated in parentheses.

Lexical Ambiguity	**Homonymy**			**Polysemy**		
Context	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**
Dominant target	559 (89)	556 (92)	552 (98)	546 (90)	549 (89)	556 (91)
Subordinate target	571 (93)	558 (95)	552 (109)	574 (96)	567 (96)	573 (95)
Unrelated target	571 (94)	574 (94)	572 (93)	566 (86)	578 (93)	567 (94)

Accuracy rates:

Similar to the reaction times data, a Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) repeated measures ANOVA was carried out with accuracy (ACC) data. The results largely mirror those obtained in the reaction times analyses. The main effect of Target type was found to be significant, [$F1(2,36) = 31.589$, MS = 31.850, $p<0.001$, $\eta_p^2=0.637$; $F2(2,58) = 7.447$, MS = 21.272, $p<0.001$, $\eta_p^2 = 0.204$]. Furthermore, the interaction effects of Ambiguity and Target type reached significant levels

(for subjects), *F1*(2,36) = 5.696, MS = 9.722, *p*<0.007, η_p^2=0 .240; *F2*(2,58) = 2.537, MS = 6.535, *p*=0.088, η_p^2 =0.080]. The accuracy data also revealed a significant interaction of Ambiguity and Context (for subjects), *F1*(2,36) = 3.235, MS = 4.002, *p*<0.05, η_p^2=0 .152; *F2*(2,58) = 1.396, MS = 2.145, *p*=0.256, η_p^2 = 0.046].

Post-hoc comparisons to further explore the main effect of Target type revealed that errors both to the dominant targets (0.75%) and the subordinate ones (1.12%) were significantly fewer than those obtained for the unrelated targets (1.79%, *p*<0.001 in both cases). In addition, the error rates for the dominant targets were significantly lower than the error rates for the subordinate targets (*p*<0.007). This significant difference in the behaviour of the two related targets was not observed in the latency data.

Newman-Keuls post-hoc comparisons were conducted to further explore the significant interaction between Lexical Ambiguity and Target type. They revealed a pattern of results identical to those obtained in the response time data. More specifically, the error rates for both dominant targets (0.98%) and subordinate targets (0.88%) for homonymous words were significantly lower than the unrelated words (2.07%; *p*<0.001 in both cases). There were no significant differences between the errors for dominant and subordinate targets for these words (*p*=0.67). Secondly, only error rates for the dominant targets for polysemous words (0.51%) were significantly lower than errors for the unrelated targets (1.51%; *p*<0.002). The accuracy rates for the subordinate targets for the polysemous words were 1.37%, which was not significantly different from the unrelated targets (*p*=0.57). Post-hoc comparisons to explore the significant interaction of Ambiguity and Context did not show any further significant results. The percentage of errors for all conditions is presented in Table 10.

Table 10 Percentage of errors for all conditions in Experiment 4.

Lexical Ambiguity	**Homonymy**			**Polysemy**		
Context	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**	**Dominant Bias**	**Subordinate Bias**	**Double-meaning/ Pun**
Dominant Target	1.05%	1.00%	0.89%	0.26%	0.84%	0.42%
Subordinate Target	0.84%	1.10%	0.68%	1.31%	1.21%	1.58%
Unrelated Target	2.26%	2.47%	1.47%	1.21%	1.53%	1.79%

3.3.3 Discussion

Interestingly, the results from Experiment 4 did not reveal any processing differences resulting from the double-meaning consistent nature of puns. While, in Experiment 3 double-meaning consistent puns were processed significantly longer than dominant-consistent contexts, the results from Experiment 4 suggest that double-meaning consistent context were processed similarly to dominant-meaning consistent contexts. However, sense-relatedness effects seem to exert continued influence on language processing during these later stages as well. To be more specific, the processing of homonymous words provided evidence for the parallel processing of the two unrelated meanings, which is consistent with the multiple exhaustive access model. On the other hand, only the dominant meanings of polysemous words showed robust priming effects during the stage of meaning integration, raising the possibility that either the subordinate senses have decayed at that later stage of processing or they are potentially realised through the dominant senses (see Klepousniotou et al., 2008).

3.4 General Discussion

The study presented in this chapter aimed to investigate the time course of meaning activation and integration during pun processing as well as the effects of sense-relatedness in that process. In order to investigate these effects we conducted two on-line experiments within a semantic priming lexical decision paradigm in which participants listened to sentences either ending on a pun or not. The results strongly suggest that the degree of relatedness between the meanings/senses of ambiguous words resulted in processing differences between polysemous and homonymous words. The results also point to the conclusion that in processing a double-meaning consistent context (i.e., a pun) holding two unrelated meanings may be less taxing for the language processor compared to holding two related senses. Lastly, the pattern of results poses a problem for any of the three compositional models for figurative language processing, namely the standard pragmatic approach, the direct access model and the graded salience hypothesis. A constructivist account of language comprehension appears to be better suited to account for our findings here.

Sense-relatedness effects

A key point of interest was to investigate sense-relatedness effects for polysemous and homonymous ambiguous words used in context. The data provide experimental support for the processing and representational differences between polysemous and homonymous

words. The pattern for polysemous ambiguous words in Experiment 3 strongly supports the re-ordered model for lexical access (Duffy et al., 1988). For these words, both dominant and subordinate senses show strong priming effects relative to the unrelated baseline. Additionally, the dominant senses show stronger priming effects than the subordinate ones that can be explained by the higher frequency of usage for these senses. In Experiment 4, however, the data for the polysemous words presented a case for selective access as only the dominant senses were maintained activated. On the other hand, the results for homonymous words display a different pattern. In Experiment 3, consistent with the exhaustive access model (Swinney, 1979) both dominant and subordinate meanings show strong priming effects relative to the baseline, but in this case the dominant meanings showed slower rise in activation relative to the subordinate ones. In Experiment 4, these words continued to show support for the exhaustive access model as again both dominant and subordinate meanings were primed but this time priming effects were of equal magnitude. Thus, we conclude that initially all senses of polysemous words were activated while in the late stages of processing only the dominant senses remained active. Conversely, all meanings of homonyms were also initially activated but surprisingly it was the subordinate meanings that were primed more strongly; however, during late processing the dominant meanings increased their activation levels and both dominant and subordinate meanings were equally primed.

The differences between the activation levels of dominant and subordinate meanings of homonyms in the two experiments together with the overall differences in the processing patterns of polysemous and homonymous words speak to the possible representational differences of the two types of ambiguous words. Firstly, it may be the case that participants realised that meanings that are not frequently used were required for appreciating the puns in the present study, which may have made them more alert to potential ambiguities and meanings that are not often used in everyday language. Such initial heightened awareness to subordinate meanings could probably have led to the faster reaction times for the subordinate meanings of homonymous words relative to their dominant ones. However, the fact that the difference is not evident for the dominant and subordinate senses of polysemous words speaks to the assumption that the senses of polysemous words share a mental representation, while the different meanings of homonymous words have separate mental representations (e.g., Klepousniotou et al., 2012). Furthermore, in Experiment 4 we did not see activation for the subordinate senses of polysemous words, whereas both dominant and subordinate meanings of homonyms showed strong priming effects, which again argues that both ambiguous words are represented differently in the mental lexicon. Arguably, the close

similarities between the senses of polysemous words do not necessitate the prolonged activation for both of these two senses, while the lack of similarities between the meanings of homonymous words suggests that it is necessary to keep both meanings active, in case of a necessary re-analysis. Overall, the pattern of the data points to the conclusion that sense-relatedness is an important variable not only during word recognition processes (Klepousniotou and Baum, 2007), but also for processing ambiguous words used in context.

Furthermore, sense-relatedness effects were also important for distinguishing between the double-meaning consistent contexts motivated by polysemous words (or, polysemous puns) and those motivated by homonymous words (or, homonymous puns) during automatic pun processing. In Experiment 3 (ISI: 0ms), polysemous puns required reliably longer processing time than homonymous puns. Additionally, polysemous puns required reliably longer processing times relative to the dominant-meaning consistent and subordinate-meaning consistent sentences that also employed polysemous ambiguous words. On the other hand, there were no differences between the processing times required for homonymous puns and the dominant-meaning consistent and subordinate-meaning consistent sentences that also employed homonymous ambiguous words. Therefore, we argue that for the language processor it was more taxing to process double-meaning consistent contexts motivated by the two related senses of a polysemous word relative to processing similar contexts motivated by the two dissimilar meanings of a homonym.

Some support for the processing disadvantage of polysemous puns comes from the possibility that processing polysemous ambiguous words taps a deeper, conceptual, level of resolving ambiguity as opposed to a more shallow, form, processing required for the disambiguation of homonyms (Ferreira, 2007). The processing costs for these puns may be associated with the need to hold two intended senses that are relatively similar but yet not identical in a contrasting punning context. Thus, it is conceivable that polysemous puns require two processing aspects that could probably be conducted in parallel, namely finding the similarity between the two senses of the polysemous word that motivates the pun and then trying to keep both activated as sufficiently different in the punning context. On the other hand, the processing advantage of homonymous puns may be explained by the assumption that one of these aspects is missing, namely we do not need to look for similarities as the two meanings of homonymous words are obviously different from one another in which case we are only required to maintain them active. It is interesting to note that the processing differences between polysemous and homonymous puns were confined to the early stages of pun

processing. Experiment 4 (ISI: 750ms) failed to provide evidence for any pun-related processing costs, which leads us to assume that the processing idiosyncrasies of the linguistic units motivating the double nature of puns are of primary importance. In other words, the double-nature of puns seems to be processed over and above the processing that is required for the linguistic units giving rise to the puns.

Puns and implications for models of figurative language processing

The results obtained from the two experiments have implications for the explanatory power of the three leading models for non-literal language processing. Even though the overall pattern of the data is more easily accommodated within interactive models for figurative language processing which argue that contextual information affects processing from the very early stages of comprehension, each one of the leading models on non-literal language processing can explain only a small part of the data. On the one hand, the results are only partially consistent with the predictions of the standard pragmatic approach (Grice, 1975) according to which non-literal language processing is costly and we would expect pun-related costs both during meaning access and meaning integration. The present findings show pun-related processing costs only for double-meaning consistent contexts motivated by polysemous words during automatic pun processing. This approach cannot explain the lack of similar costs for double-meaning consistent sentences motivated by homonymous words in Experiment 3 (ISI: 0ms) as well as the general lack of processing difficulties associated with the processing of double-meaning consistent sentences in the later stages of processing (Experiment 4, ISI: 750ms).

Even though the importance of context is evident at the automatic stages of language processing, which is consistent with the predictions of interactive models for figurative language processing, the data is again only partially consistent with the predictions of the direct access model (Gibbs, 1994). In particular, it cannot explain why polysemous puns required more processing effort. More generally however, this model assumes that there is one relevant intended message that could be accessed directly bypassing any other contextually irrelevant meanings that a language item might accidentally have. Therefore, the model relies on the assumption that successful communication is built on the premise of encoding and decoding *one* intended message. Although most examples of everyday communication comply with this expectation, pun processing cannot be easily accommodated within such a theoretical framework. Puns in general, and especially the puns used in the present study, illustrate full lexical ambiguity that cannot be resolved within the bounds of the

context provided. Thus, puns have at least two intended meanings that have to be accessed simultaneously and potentially entertained for some time in order for people to appreciate the obvious double-meaning nature of this type of language. Additionally, despite such theoretical considerations, the data of this study still do not conform to the assumptions of a strong view of direct selective access. If pun processing as evidenced in this study could be successfully explained by the direct access model, then both meanings should be accessed *simultaneously* and we would not expect to see the processing differences between the polysemous and homonymous puns in Experiment 3. Also, we would not expect to see differences in processing of polysemous puns in Experiments 3 and 4. Thus, on the basis of both the theoretical and experimental evidence discussed so far, we can conclude that the processing pattern for puns in this study cannot be accommodated by the direct access model (Gibbs, 1994).

The pattern that emerges from the present results is mostly compatible with the predictions derived from the graded salience hypothesis (GSH, Giora, 2012). According to this hypothesis, language processing is governed by two processes that operate concurrently but independently from each other, namely processes explained by contextual effects and those explained by meaning dominance (or, salience effects). The fact that polysemous puns require longer processing times relative to dominant-meaning consistent sentences using polysemous words during automatic processing is a direct result from the operations of these two processes. In particular, subordinate meanings will be accessed only after the dominant ones as they score lower on the salience scale, but since the double-meaning pun context pushes for an earlier activation of the subordinate meaning we observe the greater cognitive effort associated with puns relative to the dominant-meaning consistent context. However, even though the GSH has the power to explain the difference between polysemous puns and the dominant-meaning consistent sentences, the GSH cannot explain why polysemous puns were harder than processing subordinate-meaning consistent sentences. Additionally, the GSH cannot explain the lack of similar effects for the double-meaning consistent contexts motivated by homonymous words. The dominant senses of polysemous words and the dominant meanings of homonymous words were matched for frequency; similarly, the subordinate senses of polysemous words and the subordinate meanings of homonymous words were also matched for frequency. Thus, we argue that for double meaning consistent contexts it is the degree of sense-relatedness that affects processing rather than the degree of salience. Finally, the GSH cannot accommodate the lack of pun-related processing costs during Experiment 4 (ISI: 750ms). In particular, the GSH predicts that all meanings intended for communication will still be retained active for later processing, if they are salience based.

Therefore, according to the GSH we would expect to see pun-related costs in the late stages of processing too since the subordinate meanings are salience based and they are also clearly relevant for comprehension. The results from Experiment 4, however, failed to provide such evidence; more specifically, during late processing the subordinate meanings in the double-meaning consistent punning sentences failed to reach activation relative to the unrelated baseline, even though they are functionally important for pun processing.

A possible solution

Although the results presented here are mostly consistent with models that assign a central role to context from the very early stages of processing, such as the direct access model (Gibbs, 1994) and the GSH (Giora, 2003, 2012), neither of these models could adequately accommodate the specific double nature of puns as utterances that carry more than one intended meaning. It seems the double meaning nature of puns necessitates a model for meaning construction that respects both the immediate importance of context but is also broad enough in scope to cover the possibility for utterances to have more than one relevant and intended message. The pattern of the data in this study is more compatible with constructivist accounts for meaning comprehension which argue that context and background information are the starting point for meaning comprehension and that the intended messages conveyed by language are explained by the combination of both contextual and linguistic information (Coulson, 2001). One such possible model is the framework of conceptual blending. According to this model of meaning construction, a frame is a conceptual organisation of knowledge that can be accessed directly by linguistic utterances (Coulson, 2001). The integration of two or more such frames gives rise to a new conceptual organisation, which is also referred to as a blended space, or a hybrid frame. In particular, for two distinct frames to become a hybrid one, we minimally need four elements – a common generic space, two distinct inputs that correspond to two different frames derived from that common generic space and their joined projection into a new hybrid space, which is the blend (Fauconnier and Turner, 1998). Applied to the study of puns here, we argue that an ambiguous word represents the common generic space that has the potential of producing at least two different inputs. For example, the word ‘bank’ can be thought of as a common generic space. The potential of the common generic space of ‘bank’ is such that it would motivate the two different inputs that correspond to the two different sentences in which the same word is used with a different sense. One of the input sentences is the dominant-meaning consistent sentence and the second is the subordinate-meaning consistent sentence. Finally, the hybrid frame, or the

blend, corresponds to the double-meaning consistent sentence. It is a novel sentence in which the meanings derived from the two input sentences converge once again but are now both maintained as relevant and intended at the same time. According to the conceptual blending model, the blended hybrid frame retains features of each of the different inputs, but at the same time gains new features that are not simply the sum total of the features that existed in the input sentences. Moreover, the blended space is characterised with simplicity and compression (Fauconnier, 2005). These two are the very features we see in every pun sentence. In particular, we can understand the two different meanings that motivate the pun but we can also see at the same time that the new meaning is different from the sum total of the other two as this is the only sentence that can potentially make us laugh. Therefore, we argue that the pun sentences we used in the present study closely resemble a hybrid frame (see Figure 8 for a graphic representation of a pun as a blended space).

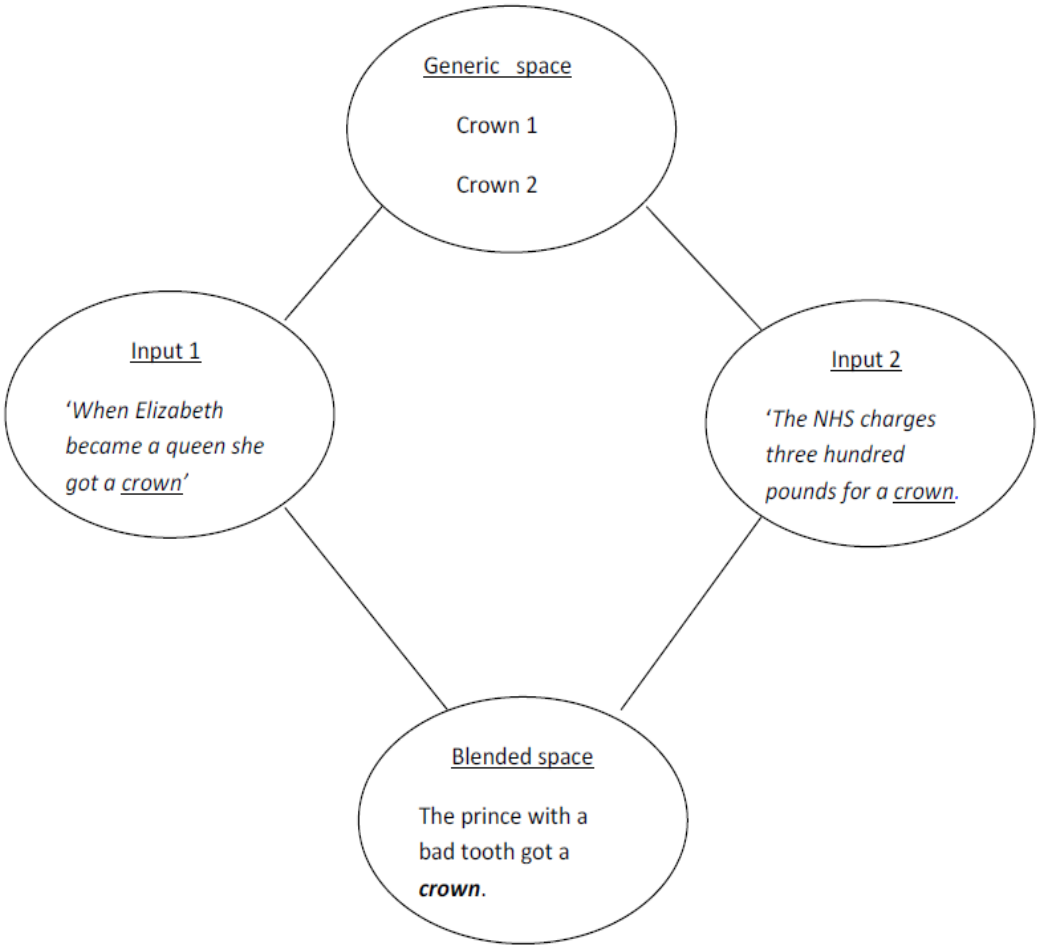

Figure 8 Graphic representation for pun construction based on the four-space model diagram adapted from Fauconnier and Turner (1998).

This model could also capture the processing and representational differences between polysemous and homonymous words by instantiating their individual characteristics in the common generic spaces for the ambiguous words (see Figure 9).

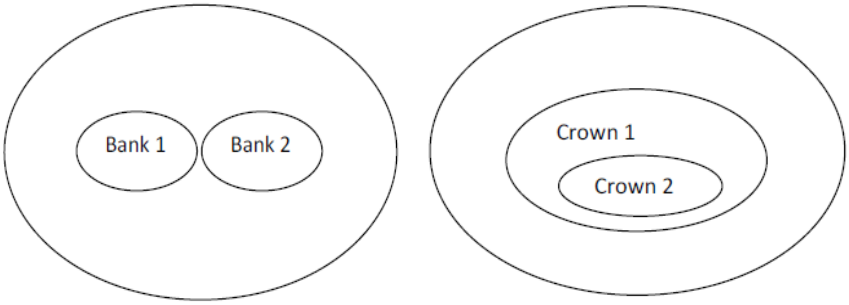

Figure 9 Representation of the two meanings of a homonymous word in generic space (left) and representation of the two senses of a polysemous word in generic space (right).

Thus, we believe the conceptual blending model can capture the processing patterns associated individually with the different input sentences, which in our case were reflected in the robust differences between the dominant-meaning consistent sentences and the subordinate-meaning consistent sentences in both experiments. More importantly, however, it can also capture the associated effort during the initial stages of the construction of the blended space, which we observed for the double-meaning consistent sentences only in Experiment 3 in the present study. The model also has the potential to capture the representational differences between polysemous and homonymous words, which we argued is what triggered the extra cognitive effort required for polysemous puns only. Overall, there is some evidence that puns might be more difficult to process compared to related non-puns, but we argue that this effort is not always required. What can predict the extra costs is associated with the processing of the underlying linguistic items motivating the pun. Thus, we conclude that the pun has a clear psychological reality but its effects are very tightly related to the processing mechanisms required for the language material that motivates it. The present findings provide evidence to argue that pun effects are observed over and above those that are associated with the processing profile of the language that motivates the pun, in this case homonymous and polysemous ambiguous words.

3.5 Conclusion

In sum, the present study provided strong evidence that sense-relatedness effects are present for ambiguous words used in context and found support for models of language comprehension that place a crucial role on context during processing. In particular, there is evidence that some puns are harder to process under automatic processing, namely polysemous puns, whereas pun-related effects were not evident in the later stages of processing. In addition, we argue that pun processing is completed in parallel, but over and above the processing that is required for the linguistic structures that motivate the punning context. Thus, on the basis of the patterns of the present study we argue that perhaps pun processing has the potential to tap into higher-level processing from the very early stages of processing.

3.6 Time-course of double meaning activation: Main findings

As discussed in the Literature Review in Chapter 1, the experimental literature on pun processing so far has failed to provide strong evidence for Right Hemisphere involvement in processing this type of non-literal language. It was hypothesized that by not looking deeper into the processing idiosyncrasies of the language that triggers the double meaning of puns we may be missing important factors influencing pun processing. In particular, given the evidence that processing idioms and ambiguous words induces RH involvement (e.g., Kempler et al., 1999 and Peleg and Eviatar, 2008 respectively), we might expect to see RH involvement for processing puns whose underlying structure is motivated by one of these two linguistic constructs. Additionally, given the evidence that processing that requires more cognitive effort benefits from recruiting RH resources (e.g., Vigneau et al., 2011), we might expect that the RH will also be recruited in the processing of puns if they prove to be more costly (under the assumption that processing two messages simultaneously may be more taxing). Before we set out to investigate whether hemispheric asymmetries were largely obscured in previous research by the fact that the linguistic structure that motivated the puns was not taken into consideration, Study 1 (Experiments 1 and 2) and Study 2 (Experiments 3 and 4) of the thesis aimed to investigate to what extent the underlying semantic nature of puns plays a role during normal inter-hemispheric processing as well as the cognitive costs it might entail. The results from these studies suggest that the internal semantics of puns plays a vital role in processing the overall dual nature of puns. The results also have implications for the processing costs

during pun comprehension and the potential of compositional models of non-literal language processing to account for the data.

The main conclusion that can be drawn from the data is that the semantic nature of the pun is an important factor for pun processing. This claim is supported by evidence from the studies that suggests that the time course of dual meaning activation differs as a function of the underlying structure of puns. In particular, relative to a single-meaning consistent baseline, some types of puns require extra processing effort (Experiment 3) while other types require less processing effort (Experiment 2), yet a third type seem to be processed similarly to single-meaning contexts (Experiment 3). In Experiments 1 and 2, we explored the time-course of meaning activation associated with puns that are motivated by the inherent ambiguity between the literal and idiomatic meanings of idioms; i.e., the pun was an utterance that expressed simultaneously an idiomatic meaning as well as the literal meanings of the words comprising the idiom. For example, we employed two types of idioms (decomposable and non-decomposable) in sentence-final position to create punning sentences such as '*Old cleaners never die, they just* ***bite the dust.'*** and '*Old skiers never die, they just* ***go downhill****.'* The results from that study revealed that during later processing stages (Experiment 2, ISI: 750ms) double-meaning consistent sentences (or puns) showed priming effects relative to single-meaning consistent baseline sentences. Such results suggest that puns were processed faster than single-meaning consistent sentences, thus arguing that puns seem to require less processing resources.

The study also aimed to investigate decomposition effects for idioms used in sentence contexts. We observed decomposition effects only in conditions concerning the later stages of processing for idioms used in single-meaning consistent sentences. In particular, the data suggest that for decomposable idioms only the literal meanings were activated, whereas for non-decomposable idioms both literal and idiomatic meanings showed activation relative to baseline. There were no decomposition effects for idioms used in double-meaning consistent puns.

It is possible that the slower time rise of idiomatic meanings and the difficulty of detecting decomposition effects during on-line idiom processing (Libben and Titone, 2008) may have obscured decomposition effects for the two types of contexts under conditions of automatic processing. It is further argued here that a more sensitive priming paradigm may be more likely to detect such effects behaviourally. Experiments 5 and 6 of this thesis employed a cross-modal half-field priming paradigm aiming to investigate further decomposition effects in

single-meaning consistent and double-meaning consistent contexts as well as the individual contributions of each hemisphere in that process.

In Experiment 3 and 4 we explored the time-course of double meaning activation associated with puns that are motivated by the multiple senses/meanings of ambiguous words; i.e., the pun was an utterance that expressed simultaneously the dominant and subordinate senses/meanings of ambiguous words. For example, we employed puns such as *'The prince with a bad tooth got a **crown**.'* in which the polysemous ambiguous word 'crown' conveys both its dominant and subordinate senses simultaneously. Similarly, in the sentence *'You pay your psychiatrist with a sanity **check***.' the homonymous ambiguous word 'check' conveys both its dominant and subordinate meanings simultaneously. However, unlike the results obtained for puns motivated by idioms, the data collected here failed to indicate that puns might require less processing resources. In particular, the results from Experiment 3 (ISI: 0ms) point to the conclusion that during automatic processing double-meaning consistent sentences that simultaneously intended the two semantically related senses of polysemous ambiguous words (i.e., polysemous puns) were responded to more slowly than single-meaning sentences implying they were harder to process. Furthermore, this effect was absent for double-meaning consistent sentences that simultaneously intended the two semantically unrelated meanings of homonymous words (i.e., homonymous puns), which showed processing times similar to single-meaning baseline sentences. Lastly, a direct comparison between polysemous and homonymous puns revealed that processing the former took significantly longer than processing the latter suggesting that holding simultaneously related senses is harder than holding simultaneously unrelated meanings. Thus, given the evidence that the Right Hemisphere is employed in processing that is more taxing (e.g., Vigneau et al., 2011), we expect RH involvement for polysemous puns, which will support the assumption that previous investigations on pun processing failed to observe RH contribution as they did not consider the internal semantics of puns.

In sum, Experiments 3 and 4 revealed a pattern of pun processing that is strikingly different from that obtained from Experiments 1 and 2. In particular, for idioms pun effects were evident during the late stages of processing, whereas for ambiguous words pun effects were evident during automatic processing. We argue that this difference between the two studies is linked to processing difference between idioms and ambiguous words, namely the idiomatic meanings of idioms are more likely to have slower time-rise than the literal meanings (e.g., Cacciari and Tabossi, 1988), while both dominant and subordinate meanings of ambiguous

words are more likely to be accessed exhaustively during automatic processing (e.g., Swinney, 1979). Since puns rely on the interplay between the two meanings that are inherent for both idioms and ambiguous words, we conclude that pun effects for idioms will be delayed relative to pun effects for lexical ambiguity.

Furthermore, the pun effects in Study 1 (Experiment 1 and 2) and Study 2 (Experiments 3 and 4) are qualitatively different from each other. To be more specific, when puns were motivated by idioms they were easier to process relative to single-meaning baseline sentences. On the other hand, when puns were motivated by polysemous words, they were processed slower relative to single-meaning baselines. Finally, when puns were motivated by homonyms, the data did not reveal any significant difference in processing from single-meaning baseline sentences. Such evidence leads to the conclusion that the semantic structure of puns is an important factor in pun processing that might lead to differing amounts of cognitive effort required for the processing of puns. Thus, given the evidence that idioms and lexical ambiguity induce RH processing when they are not used in punning contexts (see Sections 1.2.2 and 1.2.3. from Chapter 1) as well as the indication that some puns are harder to process, we have every reason to expect RH involvement for processing of puns that are motivated by idioms and ambiguous words. Employing the divided visual fields paradigm, we explored the time course of double meaning activation in the two hemispheres for puns motivated by idioms in Experiments 5 and 6, and for puns motivated by ambiguous words in Experiments 7 and 8.

In addition to the processing differences between the puns in the four experiments so far, an aspect of the results revealed an interesting finding. Processing decomposable idioms and polysemous words on the one hand and non-decomposable idioms and homonymous words on the other hand shared some similarities. In particular, when comparing the results from Experiment 2 (ISI: 750ms) and Experiment 4 (ISI: 750ms) we see that during later stages of processing for decomposable idioms and polysemous words only one meaning is activated, namely the literal meaning of decomposable idioms and the dominant sense of polysemous words. According to compositional theories of idiom processing (e.g., Holsinger, 2013), the literal meanings of idiomatic expressions are considered the dominant meanings of idioms. Thus, for both decomposable idioms and polysemous words only dominant meanings survived at the late stages of processing. Conversely, for non-decomposable idioms and homonymous words two meanings have remained activated, namely both literal and idiomatic meanings for non-decomposable idioms and dominant and subordinate meanings of homonymous words. It is claimed here that such processing similarities might be explained by similarities in mental

representations. To be more specific, neither idiomatic meanings of decomposable idioms, nor subordinate senses of polysemous words need to be represented separately in mental space. In other words, the semantic similarities between literal and idiomatic meanings of decomposable idioms, and dominant and subordinate senses of polysemous words preclude the necessity for the idiomatic meanings and subordinate senses to have a mental representation that is independent from the literal meanings and the dominant senses respectively. In both cases, activation of idiomatic meanings and subordinate senses has been achieved following an inferential/derivative mechanism. On the other hand, the idiomatic meanings of non-decomposable idioms and the subordinate meanings of homonymous words need to have separate and independent mental representations. In other words, the semantic dissimilarities between literal and idiomatic meanings of non-decomposable idioms, and dominant and subordinate meanings of homonymous words necessitate the independent mental representations of idiomatic meanings and subordinate meanings. Therefore, in addition to investigating right hemisphere involvement for polysemous puns, the studies in the next part of the thesis will explore further the similarities between polysemous words and decomposable idioms on the one hand, and homonymous words and non-decomposable idioms on the other. It is speculated that though the underlying semantic nature of puns is an important factor to be considered during pun processing, it may not be revealed by differences between linguistic constructs such as idioms and ambiguous words that motivate puns, but rather by how semantically similar or different the two meanings that create the duality of the pun are.

The overall pattern of results from the four experiments so far has implications for the explanatory potential of the leading compositional models of non-literal language processing, namely the standard pragmatic approach (Grice, 1975), the direct access model (Gibbs, 1994) and the graded salience hypothesis (Giora, 2012). Predictions drawn from any one of these models cannot easily accommodate the above main findings. In particular, according to the standard pragmatic approach (Grice, 1975), processing non-literal language requires an obligatory first stage of processing the literal language that the particular non-literal expression deviates from thus predicting processing costs associated with pun comprehension both during early and late processing. However, the results revealed processing costs only for puns motivated by the multiple senses of polysemous words during automatic processing. The standard pragmatic approach also predicts that these processing costs will be evident during late processing too, which, however, has not been supported by the data. Additionally, this model cannot explain why similar processing costs were not evident for puns motivated by the

different meanings of homonymous words. Indeed, processing puns based on the different meanings of homonymous words did not show any processing differences from the unrelated baseline both during early and late processing. Finally, the standard pragmatic approach to non-literal language processing cannot explain two aspects of the data obtained from puns based on idiomatic expressions either. Firstly, during automatic processing these puns did not show any processing differences relative to baseline processing, whereas during the later processing stages, puns motivated by idiomatic expressions were faster, hence easier, to process relative to single-meaning baseline sentences. Therefore, in sum the standard pragmatic approach (Grice, 1975) can only explain a small fraction of the whole data set obtained from the experiments so far.

Similarly, the direct access model (Gibbs, 1994), which postulates that processing non-literal language is not different from processing literal language, can only explain a small portion of the data set. In particular, it can only account for the findings that (i) processing puns motivated by the multiple meanings of homonymous words is not different from processing baseline single-meaning consistent sentences both during early and late processing, and (ii) the lack of processing differences between puns motivated by idiomatic expressions and single-meaning consistent baselines during automatic processing. However, the direct access model runs into difficulties explaining the finding that during the later stages of processing, puns motivated by idiomatic expressions were faster to process relative to non-punning single-meaning baseline sentences. Moreover, this model cannot explain the results obtained for polysemous puns which revealed that during automatic processing these puns were significantly more taxing. In sum, even though the direct access model can account for those parts of the data that the standard pragmatic approach left unaccounted for, this model cannot explain the overall pattern of results for processing puns. Perhaps most importantly the direct access model does not predict differences in processing costs for pun comprehension between the automatic and controlled stages (investigated by the two ISIs), something that is clearly evident in both Studies 1 and 2.

Finally, the graded salience hypothesis (e.g., Giora, 2012) runs into similar difficulties in accounting for the data as those discussed for the standard pragmatic approach. According to that hypothesis non-literal language is processed according to two influences, namely context and salience thus predicting processing costs for puns both during early and late processing due to the competition between the two meanings of puns rendered by the fact that punning contexts prime two meanings simultaneously irrespective of their salience. However, since the

graded salience hypothesis is the only model that takes into consideration lexical features such as salience, it encounters an additional difficulty. In particular, it is not clear why during automatic processing for puns motivated by ambiguous words there will be processing differences between puns motivated by polysemous words and those motivated by homonymous words. According to Giora (1997; 2012) more salient meanings score higher for familiarity and frequency than less salient meanings. The results from the rating studies conducted to norm the stimuli used in Study 2 revealed that the scores for familiarity of the dominant senses of polysemous words is comparable to the degree of familiarity for the dominant meanings of homonymous words. Similarly, the familiarity score of the subordinate senses of polysemous words is comparable to the familiarity score of the subordinate meanings of homonymous words. Thus, we claim here that the processing differences between polysemous and homonymous puns cannot be due to different degrees of salience. Additionally, the graded salience hypothesis cannot account for the fact that the greater processing costs required for the polysemous puns during automatic processing disappeared during the later processing stages. In sum, even though the graded salience hypothesis appears the most flexible model that could account for pun processing since it is the only model that takes into account both the influence of context and that of linguistic structure, the overall pattern of the results still cannot be accounted for successfully in this framework.

It is possible that the overarching reason for the inability of the three compositional models to account fully for the data from Studies 1 and 2 is their implicit assumption that non-literal language aims to convey *only one* meaning that is somehow different from the literal interpretation (or not different in the case of the direct access model). However, in the case of puns, there are at least *two* intended meanings and one of them is necessarily very similar to literal language, or language with a high degree of familiarity and frequency of usage. It is tentatively claimed here that the dual nature of puns investigated in the studies so far resulted in a complex pattern of data that requires a more comprehensive model of meaning construction. In particular, the model that might successfully explain pun comprehension needs to be able to appreciate simultaneously differences in the underlying semantic nature of the two meanings that constitute and motivate the pun, the very early importance of contextual influence, and last but not least the gestalt nature of puns too. According to Harder (2003), more complex models and theories should only be resorted to in cases when simple and more elegant models cannot explain complex patterns of data. It is argued here that the case of puns is one such example that necessitates a more complex and more comprehensive model to account for the data gathered in the studies 1 and 2. It has also been suggested that

the model of conceptual blending (Coulson, 2001), which holds that meaningful schemas could be integrated and blended in various ways to construct meaning, seems better suited to explain the present pattern of results as it encompasses both linguistic and contextual factors in the comprehension process. In other words, conceptual bending takes into account both the importance of context and the inherent meaningful structure of language in the process of meaning construction. In order to investigate further the explanatory power of current compositional models and conceptual blending, an electrophysiological study was designed to explore the neural correlates of pun processing relying on measurements such as the N400 and P600 components of event-related potentials (see Experiment 9).

To sum up, Studies 1 and 2 present convincing evidence that the underlying structure of puns is an important factor that affects inter-hemispheric processing. The following two studies of this thesis (Chapters 4 and 5) will investigate further the hypothesis that previous experimental investigations on pun processing obscured RH involvement by not considering carefully the linguistic structure of the pun. In other words, by exploiting the inherent ambiguity of idiomatic expressions (Experiments 5 and 6 in Chapter 4) and words with multiple meanings (Experiments 7 and 8 in Chapter 5), both of which are known to induce right hemisphere processing, we attempted to create optimal conditions for detecting possible right hemisphere involvement during the processing of puns motivated by these linguistic constructs.

Chapter 4. Cerebral asymmetries for processing puns motivated by idiomatic expressions

4.1 Introduction

The left hemisphere (LH) has been regarded unanimously as dominant for language processing. Recently, a growing body of research has shown that the right hemisphere (RH) also contributes to language comprehension in an important and collaborative way (e.g., Beeman et al., 1994; Beeman and Chiarello, 1998; Burgess and Chiarello, 1996). Most notably, the available evidence suggests that the RH contributes to aspects of non-literal language processing, which became known as the RH hypothesis (Giora, 2007). For example, differential involvement of the RH is evident during metaphor comprehension (Bottini, Corcoran, Sterzi, Paulesu et al., 1994; Faust and Mashal, 2007; Klepousniotou, Gracco and Pike, 2014; Mashal et al., 2008; but cf. Stringaris et al., 2007 for an alternative view that holds that the RH is not specifically involved in metaphor processing), as well as idiom processing (Van Lancker and Kempler, 1987; Van Lancker-Sidtis, 2006) and joke comprehension (Coulson and Wu, 2005; Coulson and Williams, 2005; Marinkovic et al., 2011; Shammi and Stuss, 1999). Even though there is compelling experimental and theoretical evidence in support of RH involvement during non-literal language processing, idiom processing and joke comprehension, two of the existing investigations on puns indicate that puns are processed primarily by the language-dominant LH (Coulson and Severens, 2007; Kana and Wadsworth, 2012). However, according to Goel and Dolan (2001) phonological jokes (or puns) were processed in the language-dominant LH, whereas semantic jokes were processed bilaterally. Thus, it is hypothesised that if the internal structure of jokes can affect hemispheric processing for jokes in general, it is possible that the internal structure of puns can also affect hemispheric processing. This chapter of the thesis focuses specifically on hemispheric differences during the processing of puns that are motivated by the inherent ambiguity between the literal and idiomatic meanings of idioms.

Research investigating the processing of idioms in the cerebral hemispheres has produced mixed and conflicting results regarding which hemisphere is predominantly involved in their processing. Early neuropsychological evidence pointed to the non-dominant RH as the responsible one for the processing of this type of language (Kempler et al., 1999; Van Lancker and Kempler, 1987). For example, Van Lancker and Kempler (1987) reported that in a picture-matching comprehension task Left Brain Damaged (LBD) patients were more likely than Right Brain Damaged (RBD) patients to preserve comprehension of familiar idiomatic expressions. Additionally, LBD patients were less likely than RBD patients to preserve comprehension of

novel sentences. The researchers concluded that since LBD patients were more likely to exhibit preserved comprehension skills of familiar idiomatic expressions relative to the RBD group, these phrases are most likely stored and processed differently from novel sentences hence predominantly in the RH. However, more recent lesion studies with aphasic patients suggest that it is in fact the LH that governs idioms processing (e.g., Nenonen et al., 2002; Papagno et al., 2004; Papagno and Genoni, 2004). In addition, evidence from research relying on other methodologies and recruiting healthy adults also supports the assumption that idioms are processed in the language dominant LH. For example, during a sentence comprehension task Kana et al. (2012) collected fMRI data from participants who read sentences containing either idiomatic phrases or literal control sentences for which participants had to answer a yes/no comprehension question. The results indicated that sentences containing idiomatic expressions recruited mostly LH regions such as the left temporal cortex, left thalamus and the left inferior frontal gyrus. Kana et al. (2012) concluded that the processing of idiomatic phrases most likely relies on the same neural networks used for processing literal language.

In contrast to both these assumptions (i.e., idioms are processed in the realm of the RH or the LH), a representative body of research has recently compiled evidence that processing idiomatic expressions requires a more widely distributed neural network encompassing both hemispheres. This claim is supported by neuropsychological data (Papagno et al., 2006; Burgess and Chiarello, 1996), fMRI data (Romero Lauro et al., 2008), data from a repetitive TMS study (Rizzo et al., 2007), as well as electrophysiological data (Proverbio et al., 2009). For instance, in an investigation of the time-course and neural bases of idiomatic language processing, Proverbio et al. (2009) asked participants to read silently sentences ending on an idiomatic expression while the researchers recorded Event Related Potentials (ERPs). Half of the sentences conveyed a literal meaning, whereas the other half primed the idiomatic meaning of the preceding idiom. Participants had to perform a semantic judgement on a target word that was either associated to the meaning of the preceding sentence or was unrelated. The results from the behavioural data showed that responses made to targets after literal sentences were significantly faster than responses made after idiomatic sentences. The electrophysiological data for the N400 component did not show any differences between the sentence types in terms of the latency of the negative deflection. Conversely, the amplitude of the N400 component was much larger for the idiomatic sentences relative to the literal ones suggesting that processing the idiomatic sentences was more effortful. Furthermore, a source analysis of these N400 differences revealed that the neural generators included the left and right occipital lobe, the left and right temporal lobe, the right parahippocampal region, the

right middle temporal gyrus and the left middle frontal gyrus. Proverbio et al. (2009) concluded that around 400ms into the processing of idiomatic expressions bilateral brain areas are recruited with larger effects over the right hemisphere. In sum, then, the experimental evidence on idiom processing in the two hemispheres is not in agreement yet as to which hemisphere is differentially involved in idiomatic processing, even though the most recent evidence points in the direction of bilateral processing. Therefore, if idioms are the underlying motivation of the double-meaning nature of puns, then we might expect that the right hemisphere will be involved during the processing of these puns as well.

One reason for such conflicting results could be the fact that idiomatic expressions comprise a large set of fixed expressions characterised by their multidimensional nature (Canal et al., 2010; Libben and Titone, 2008), which is not always taken into consideration. In particular, idioms vary in terms of their familiarity, predictability, decomposability, literal plausibility, ambiguity, semantic opacity, grammatical well-formedness, and syntactic flexibility to mention but a few important variables. There is experimental evidence suggesting that different types of idioms might recruit different neural networks. For example, highly ambiguous idioms such as *kick the bucket,* have been reported to recruit RH neural substrates, whereas low ambiguous idioms such as *feel under the weather,* have been reported to rely on the language dominant LH (Briner and Virtue, 2014; Papagno and Cacciari, 2010; Zempleni et al., 2007). Along similar lines, Sela, Ivry and Lavidor (2012) provide data that argue that more predictable idioms are more likely to be processed by the LH, while less predictable/unpredictable idioms are more likely to be processed by the RH. The variable that is of most relevance to the current thesis is idiom decomposition. According to Gibbs et al (1989a), if an idiom is decomposable, such as *pop the question,* the meanings of the components of that idiom contribute in an obvious way to the overall idiomatic meanings. Conversely, for non-decomposable idioms, such as *kick the bucket,* it should be relatively hard for people to see how the idiomatic meaning is distributed over the meanings of the component words (see Chapter 1 for a more detailed description of decomposition effects). Studies investigating the importance of idiom decomposition during on-line idiom processing have produced mixed results. Originally, Gibbs et al (1989a) argued that decomposable idioms show a processing advantage relative to non-decomposable idioms due to the similarities between the literal and idiomatic meanings of this type of idioms. On the other hand, studies challenged the importance of idiom decomposition during on-line processing claiming that people are not aware of this variable and it does not affect processing of idioms (Libben and Titone, 2008; Tabossi et al., 2008). More recently, Cieslicka (2013) reported evidence that points to the assumption that it may be non-

decomposable idioms that show a processing advantage compared to decomposable idioms. Chapter 2 from this thesis presented data that support Cieslicka's (2013) assumption.

Cieslicka (2013) employed a half-field priming paradigm to investigate the hemispheric differences during the time-course of meaning activation of these two types of idioms used in ambiguous (neutral) and unambiguous (idiomatic) sentence contexts. Decomposable and non-decomposable idioms were matched for ambiguity, familiarity and predictability. They were used in sentence-final position in such a way that for half of the sentences the preceding context was neutral and did not bias either the literal or idiomatic meaning, while for the other half the preceding context primed the idiomatic meaning. The sentences were followed by targets either related to the literal meaning or to the idiomatic meaning. In order to investigate different stages in on-line idiom processing, in Experiment 1 the targets followed immediately at the offset of the sentence (ISI: 0ms) and in Experiment 2 there was a delay of 400ms between the offset of the sentence and the presentation of the target (ISI: 400ms). The results from Experiment 1 (ISI: 0ms) revealed that both contexts successfully primed only the idiomatic meanings of non-decomposable idioms in the RH, while the idiomatic meanings of decomposable idioms did not show activation. Experiment 2 (ISI: 400ms) showed that in ambiguous (neutral) contexts, the LH activated only the literal meanings of decomposable idioms, whereas the RH activated both literal and idiomatic meanings of these idioms. No activation for either meaning in either hemisphere was found for the non-decomposable idioms. Conversely, in unambiguous (idiomatic) contexts, the LH activated only the literal meanings of both decomposable and non-decomposable idioms, and the RH activated only the literal and idiomatic meanings of the non-decomposable idioms. On the basis of these results, Cieslicka (2013) argued against the predictions of the Decomposition Hypothesis (Gibbs, 1989a) according to which decomposable idioms are expected to show a processing advantage over non-decomposable ones. The researcher further claimed that these results were modulated by context and hemisphere, with idiomatic meanings of non-decomposable idioms being activated only in the RH, in both neutral and idiomatic contexts across the two ISIs. Cieslicka (2013) concluded that the RH may be more adept at processing non-decomposable idioms, while there is no evidence that the LH may be better at processing decomposable idioms. Therefore, if the RH is better at processing non-decomposable idioms in neutral and idiomatic contexts both during the early and late stages of processing, it would be interesting to investigate whether puns motivated by sentence-final non-decomposable idioms might also exhibit right hemisphere involvement during the early and late stages of processing.

Thus, the present study was designed to investigate the hemispheric differences in the time-course meaning activation for double-meaning consistent contexts (or puns) motivated by decomposable and non-decomposable idioms. Two half-field cross-modal priming lexical decision experiments were designed in which participants listened to sentences ending with an idiom when it was (i) used idiomatically (single-meaning idiomatic contexts), or (ii) used in a way in which both idiomatic and literal meanings of the idiom were intended as equally consistent (double-meaning consistent sentences, or puns). Each sentence was followed by the visual lateralized presentation of a target word related to (i) the idiomatic meanings (idiomatic target); (ii) to the literal meaning of the idioms' component words (literal target); or (iii) was unrelated. In Experiment 5, the target words were presented immediately at the end of the sentence (ISI: 0ms) in order to investigate the early automatic stages of language processing. In Experiment 6, the presentation of the targets was delayed; they were presented 750ms after the end of the sentence to tap into the later stages of processing. Consistent with the results we presented in Chapter 2, we expect the current study to provide further support for the assumption that the degree of idiom decomposition affects on-line idiom processing. Under the assumption that non-decomposable idioms are more likely to engage RH processing resources relative to decomposable idioms both in ambiguous and unambiguous contexts (Cieslicka, 2013), we expect that double-meaning consistent punning contexts motivated by non-decomposable idioms are more likely to show RH involvement relative to double-meaning consistent contexts motivated by decomposable idioms. Furthermore, as the double-meaning consistent sentences in the present study are motivated by the interplay between literal and idiomatic meanings we expect to see a more prominent RH involvement in Experiment 6 (ISI: 750ms) due to a possible slower time rise of the idiomatic meanings of decomposable idioms (Cieslicka, 2013).

4.2 Experiment 5

4.2.1 Method

Participants:

Twenty native speakers of English (9 male and 11 female) with an average age of 22.2 years (range 19-32) and an average of 14.9 years of education (range 13-17) took part in the experiment for remuneration. All participants were right-handed, as assessed according to the Handedness Inventory by Briggs and Nebes, 1975, with normal or corrected to normal vision and no history of either neurological or language impairments. The experiment received

approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Design and Materials:

The study had a within-subjects design with four factors: Decomposition, with two levels (decomposable idioms/non-decomposable idioms) specifying the type of idiom used in each sentence context; Context, with two levels (idiomatic single-meaning consistent and punning double-meaning consistent); Target type, with three levels (idiomatic-related, literal-related and unrelated), specifying the type of meaning facilitated in each context; and Visual Field (left visual field, right visual field), specifying the visual field of target presentation. The study used the same materials as in the earlier study that relied on the cross-modal semantic priming paradigm with central presentation of targets (see Design and Materials in Chapter 2, Experiments 1 and 2). The primary dependent measure was response latencies but accuracy rates were also recorded and analysed.

Procedure:

Stimuli were counterbalanced over three lists (List A, List B and List C) and the items in each list were pseudo-randomised so that no three stimuli of the same type occurred consecutively. Participants had to attend three sessions separated by at least a week in order to complete the experiment and were tested individually in each session. Each session lasted approximately 50 minutes and participants were asked to complete one list of the stimuli each time. The order of presentation of the stimuli lists was also counterbalanced. The completion of one session consisted of 480 trials split in two blocks of 240 trials in each. Half-way through the session (between the two presentation blocks) there was a short in-built break during which participants were instructed to rest their eyes but not leave their seat. The completion of the experiment required 1440 trials. The presentation of the stimuli as well as recording of the reaction times and the error rates were controlled by E-Prime2.

Participants were seated in a comfortable position in front of the computer monitor approximately 57cm away from the screen. They received oral instructions that were reinforced in a written form at the very beginning of the experiment. The instructions informed them that they would use headphones to listen to sentences that would be followed by a word presented visually on the computer screen. They were also informed that the word would flash very quickly either to the right-hand side or to the left-hand side of a fixation cross that remained in the centre of the screen throughout the experiment. Participants were asked

to listen carefully to each sentence and decide whether the word that appeared visually at the end was a real word in English or not. They had to indicate their decisions by clicking the relevant mouse-buttons as quickly and as accurately as possible. The experiment began with a practice block consisting of 11 sentences to allow participants to familiarise themselves with the task. Each trial began with the presentation of a fixation cross for 500ms that appeared in the centre of the screen and remained visible for the duration of the entire experiment. Participants were instructed and trained to keep their eyes fixated on the cross during the experiment and refrain from moving. Fixation time was followed by the aural presentation of the priming sentence (between 3 and 5 seconds). Immediately at the end of the sentence, with an inter-stimulus interval of 0ms (ISI: 0ms) the target appeared either in the left or right visual field. Target stimuli were visually presented for 150ms with 2.0 degrees foveal eccentricity from the fixation cross. As soon as participants responded, or at the end of 1700ms if they failed to indicate any decision, the next trial started automatically after a delay of 200ms.

4.2.2 Results

Non-experimental stimuli (all filler sentences followed by non-words) were removed from the analyses. Prior to statistical analyses, errors (7%) and outliers (3.6%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Decomposition: decomposable idioms, non-decomposable idioms) x 2(Context: idiomatic single-meaning, punning double-meaning consistent) x 3(Target type: idiomatic-related, literal-related and unrelated) x 2(Visual Field: left visual field, right visual field) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls ($p<.05$) post-hoc tests.

Response Latencies:

The Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiomatic single-meaning consistent, punning double-meaning consistent) x Target type (idiom-related, literal-related and unrelated) x Visual Field (left visual field, right visual field) ANOVA carried out with reaction time (RT) data revealed significant main effects of Target type [$F1(2,38) = 10.423$, MS = 13071, $p<0.0001$, $\eta_p^2 = 0.354$; $F2(2,58) = 4.49$, MS = 18195, $p<0.01$, $\eta_p^2 = 0.134$] and Visual Field [$F1(1.19) = 29.212$, MS = 32556, $p<0.0001$, $\eta_p^2 = 0.606$; $F2(1,29) = 42.88$, MS = 52762, $p<0.0001$, $\eta_p^2 = 0.597$]. The two-way interaction of Decomposition and Target type also

reached significant levels [*F*1(2,38) = 12.528, MS = 8013, *p*<0.0001, η_p^2 = 0.397; *F*2(2,58) = 3.01, MS = 13439, *p*<0.057, η_p^2 = 0.094]. Additionally, there were significant three-way interactions of Decomposition, Context and Target type [*F*1(2,38) = 4.178, MS = 1821, *p*<0.022, η_p^2 = 0.180; *F*2(2,58) = 3.14, MS = 4075, *p*<0.05, η_p^2 = 0.099], Decomposition, Context and Visual Field [*F*1(1,19) = 16.327, MS = 13919, *p*<0.0001, η_p^2 = 0.462; *F*2(1.29) = 27.79, MS = 25366, *p*<0.0001, η_p^2 = 0.471], as well as Context, Target type and Visual Field (only by subjects) [*F*1(2,38) = 3.734, MS = 3057, *p*<0.033, η_p^2 = 0.164; *F*2(2,58) = 2.96, MS = 4656, *p*=0.06, η_p^2 = 0.093].

Post-hoc tests to further investigate the significant main effects of Target type revealed that reaction times for literal targets (582ms) were significantly faster than unrelated targets (598ms, *p*<0.0006) while idiomatic (597ms) and unrelated targets did not differ from each other (*p*=0.804). Additionally, post-hoc tests to explore further the significant main effect of visual field revealed that responses made for targets presented in the right visual field-LH (584ms) were significantly faster than responses in the left visual field-RH (601ms, *p*<0.0002), which is consistent with the LH advantage for language processing.

Post-hoc tests to investigate the significant interaction of Decomposition and Target type revealed the following two patterns. For decomposable idioms, reaction times for literal targets (578ms) were significantly faster than unrelated targets (593ms, *p*<0.0003) whereas reaction times for idiomatic targets (606ms) were significantly slower than unrelated targets (*p*<0.049) suggesting interference effects for the idiomatic meanings of decomposable idioms. In contrast, for non-decomposable idioms, reaction times for both literal (587ms) and idiomatic targets (588ms) were significantly faster than unrelated targets (600ms; *p*<0.008 and *p*<0.01 respectively). Therefore, the data indicates that although the literal meanings of both types of idioms were facilitated, it was only the idiomatic meanings of non-decomposable idioms (and not decomposable idioms) that showed a processing advantage.

Post-hoc tests to explore further the significant interaction of Decomposition, Context and Target type revealed interesting context effects. For decomposable idioms, in idiomatic contexts, literal targets (580ms) showed facilitation relative to unrelated targets (593ms, *p*<0.05), while idiomatic targets (606ms) showed a trend for interference, i.e. a tendency to be slower than unrelated targets (*p*=0.09). In double-meaning punning contexts, literal targets (576ms) showed robust priming effects relative to unrelated targets (600ms, *p*<0.0004), while

idiomatic targets (606ms) did not differ from unrelated targets (p=0.378), indicating that the punning context benefitted slightly the idiomatic meanings (i.e., there were no interference effects). For non-decomposable idioms, the context effects suggested a different pattern. In particular, in idiomatic contexts, both literal (587ms) and idiomatic targets (584ms) showed strong priming effects relative to unrelated targets (605ms; p<0.006 and p<0.001 respectively). However, in double-meaning punning contexts, neither literal (586ms) nor idiomatic targets (593ms) were facilitated compared to unrelated targets (595ms; p=0.275 and p=0.637 respectively) indicating that the double-meaning punning context slowed down the processing of the two meanings (see Figure 10). These results suggest that pun contexts affect the processing of non-decomposable and decomposable idioms in different ways, possibly indicating differences in the underlying processing mechanisms for the two types of idioms.

Post-hoc tests to further explore the significant interaction of Decomposition, Context and Visual Field revealed the following hemispheric asymmetries. Decomposable idioms in single-meaning idiomatic contexts were processed by the LH (580ms) significantly faster than they were processed by the RH (605ms, p<0.002) indicating a LH advantage. However, decomposable idioms in punning double meaning consistent contexts were processed equally fast by the two hemispheres (p=0.728) indicating a more bilateral processing for decomposable puns. On the other hand, non-decomposable idioms in single meaning idiomatic contexts were processed equally fast by the two hemispheres (p=0.310), whereas non-decomposable idioms in punning double-meaning consistent contexts were processed significantly faster by the LH (577ms) than the RH (606ms, p<0.0006). Thus, the data suggested the bilateral processing of decomposable puns, and a LH preference for the processing of non-decomposable puns (see Figure 11).

Lastly, post-hoc tests to explore further the significant interaction of Context, Target type and Visual Field revealed the following hemispheric asymmetries for the different targets in the two sentential contexts. In idiomatic contexts, the LH did not show priming effects either for the idiomatic targets (588ms) or the literal targets (577ms) relative to the unrelated targets (587ms; p=0.898 and p=0.137 respectively). In the same contexts, the RH showed priming effects only for the literal targets (590ms) relative to the unrelated targets (611ms, p<0.04) while the reaction times of idiomatic targets (602ms) were not statistically different from unrelated ones (p=0.359). In double-meaning consistent punning contexts, the LH showed activation for the literal targets (566ms) relative to the unrelated targets (594ms, p<0.001), while the reaction times for the idiomatic targets (595ms) were similar to the unrelated targets

(*p*=0.860). In the same contexts, the RH did not show activation either for literal (596ms) or idiomatic targets (604ms) relative to unrelated targets (601ms; *p*=0.406 and *p*=0.890 respectively) (see Figure 12). Thus, although the RH showed preference for literal targets in idiomatic contexts, it was only the LH that showed preference for the same targets in double-meaning consistent contexts suggesting a LH advantage for the processing of double-meaning consistent contexts especially during the processing of literal meanings. Mean reaction times for all conditions are presented in Table 11. Additionally, Table 12 presents all the significant main and interaction effects from Experiment 5 in comparison to the main and interaction effects observed in Experiment 1 in which we used semantic priming with central presentation for the targets.

Table 11 Mean RTs (ms) for all conditions in Experiment 5. Standard deviations are indicated in parentheses.

Decomposition	**Decomposable idioms**				**Non-decomposable idioms**			
Context	**Single-meaning/Idiom**		**Double-meaning/Pun**		**Single-meaning/Idiom**		**Double-meaning/Pun**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Target Idiomatic	621 (78)	593 (88)	607 (98)	607 (75)	585 (74)	583 (74)	603 (85)	585 (76)
Target Literal	594 (81)	568 (80)	584 (78)	571 (79)	588 (74)	589 (79)	612 (92)	562 (69)
Target Unrelated	605 (80)	583 (87)	597 (85)	606 (88)	622 (95)	595 (81)	609 (91)	585 (83)

Table 12 Significant main and interaction effects from Experiment 1 (early processing of idiomatic puns with central presentation for the targets) and Experiment 5 (early processing of idiomatic puns with lateralised presentation for the targets).

Experiment 1	**Main and interaction effects**	**Degrees of freedom**	***F* value**	**MS**	***P***	η_p^2
	Target type	2,38	4.128	1944	0.024	0.178
Experiment 5	**Target type**	2,38	10.423	13071	0.0001	0.354
	Visual Field	1,19	29.212	32556	0.0001	0.606
	Decomposition X Target type	2,38	12.528	8013	0.0001	0.397
	Decomposition X Context X Target type	2,38	4.178	1821	0.022	0.180
	Decomposition X Context X Visual Field	1,19	16.327	13919	0.0001	0.462
	Context X Target type X Visual Field	2,38	3.734	3057	0.033	0.164

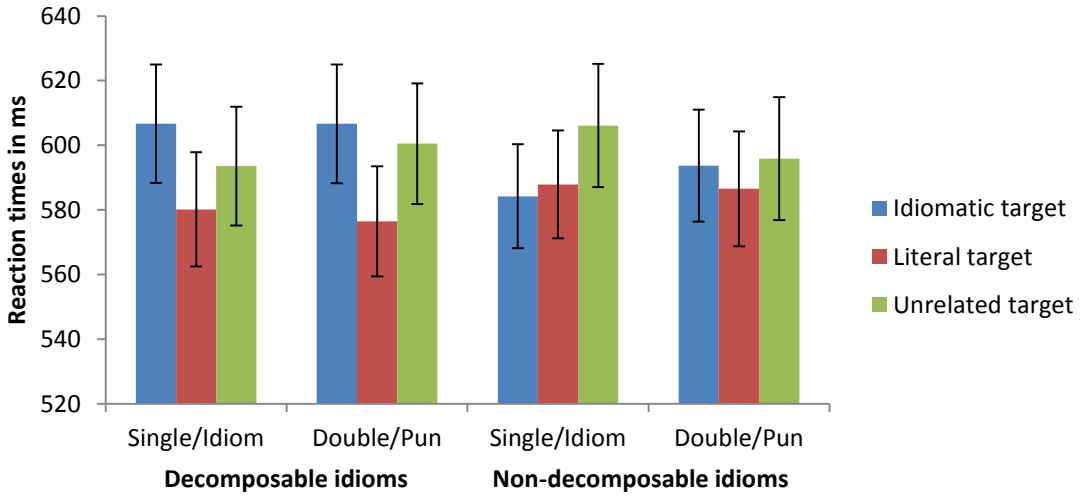

Figure 10 Mean RTs (ms) for the idiomatic, the literal and the unrelated targets for decomposable and non-decomposable idioms in single-meaning idiom and the double-meaning pun contexts. Error bars indicate the standard error of the mean per condition.

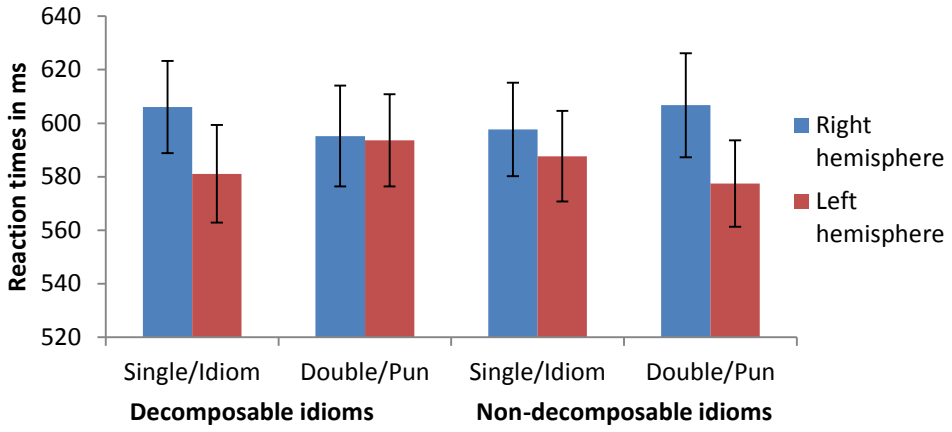

Figure 11 Mean RTs (ms) for decomposable and non-decomposable idioms in single-meaning idiom and double-meaning pun contexts in the two hemispheres. Error bars indicate the standard error of the mean per condition.

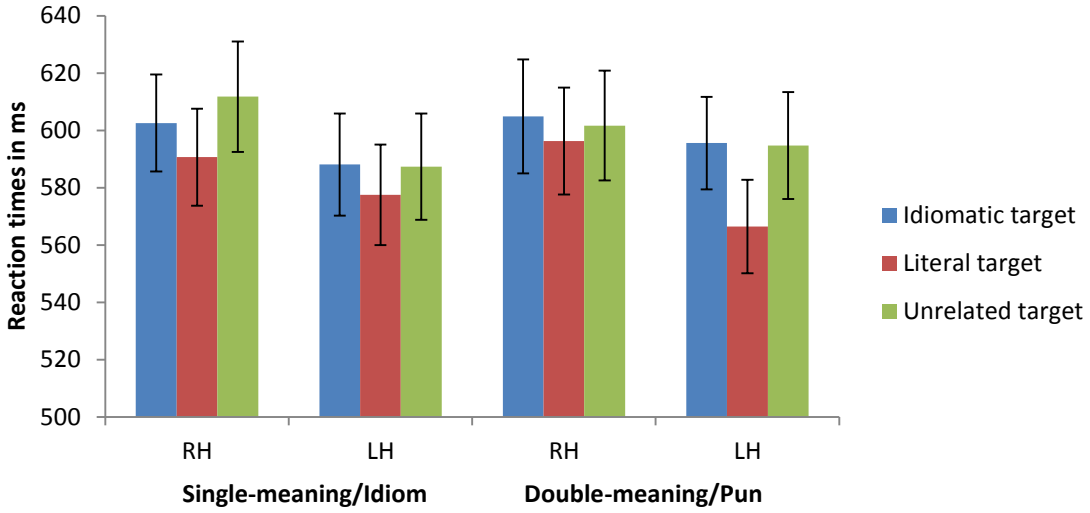

Figure 12 Mean RTs (ms) for the idiomatic, the literal and the unrelated targets in single-meaning idiom contexts and double-meaning pun contexts in the two hemispheres. Error bars indicate the standard error of the mean per condition.

Accuracy rates

Similar to the reaction times data, the Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiom consistent, double-meaning consistent) x Target type (idiom-related, literal-related and unrelated) x Visual Field (left visual field, right visual field) ANOVA carried out with accuracy (ACC) data revealed a significant two-way interaction of Decomposition and Target type [$F1(2,38) = 9.39600$, MS = 15.152, $p<0.0005$, $\eta_p^2 = 0.331$; $F2(2,58) = 3.42693$, MS = 10.101, $p<0.039$, $\eta_p^2 = 0.106$], and a significant three-way interaction

of Decomposition, Context and Visual Field [$F1(1,19) = 9.29451$, MS = 14.700, $p<0.007$, $\eta_p^2 = 0.328$; $F2(1,29) = 6.80176$, MS = 9.800, $p<0.014$, $\eta_p^2 = 0.189$].

Post-hoc tests to explore further the significant interaction of Decomposition and Target type revealed the following patterns of activation. For decomposable idioms, there were no differences in error rates neither for idiomatic (2.37%) nor for literal targets (1.87%) compared to unrelated targets (1.97%; $p=0.128$ and $p=0.621$ respectively). For non-decomposable idioms, error rates only for idiomatic targets (1.77%) were significantly lower than unrelated targets (2.48%, $p<0.012$), whereas error rates for literal targets (2.29%) were not statistically different from unrelated targets ($p=0.583$). Therefore, the accuracy data further supports the finding that non-decomposable idioms show a processing advantage over decomposable idioms. Post-hoc tests to explore further the significant three-way interaction of Decomposition, Context and Visual Field did not reveal any significant differences. The percentage of errors for all conditions is shown in Table 13.

Table 13 Percentage of errors for all conditions in Experiment 5.

Decomposition	**Decomposable idioms**				**Non-decomposable idioms**			
Context	**Single-meaning/Idiom**		**Double-meaning/Pun**		**Single-meaning/Idiom**		**Double-meaning/Pun**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Target Idiomatic	2.35%	2.00%	2.70%	2.45%	1.45%	1.75%	2.05%	1.85%
Target Literal	2.60%	1.45%	1.70%	1.75%	2.30%	2.20%	2.45%	2.20%
Target Unrelated	2.25%	1.90%	1.70%	2.05%	1.90%	2.65%	3.10%	2.30%

4.2.3 Discussion

The overall pattern of results suggests that the degree of idiom decomposition is an important factor during on-line idiom processing. In particular, consistent with previous experimental evidence the data are in accord with the assumption that, in idiomatically biased contexts, non-decomposable idioms are processed faster than decomposable idioms (Cieslika, 2013). Most importantly, however, in punning contexts, the decomposable idioms (i.e., decomposable puns) required a bilateral network for processing, whereas non-decomposable

puns recruited mostly LH resources. In order to investigate to what extent such cerebral asymmetries are confined to the early stages of meaning activation and how they may be affected in later stages of processing, we designed a second experiment that focused on another time window during the on-line processing of idioms. In Experiment 6, we increased the delay for target presentation from 0ms to 750ms to target the later stages of language processing. It was expected that further evidence for the importance of idiom decomposition during online processing would be attested both in single meaning and double-meaning punning contexts. Based on the findings of Experiment 5, it was predicted that if the RH shows preferential processing for punning contexts, then it should be mostly evident for conditions that employ decomposable idioms.

4.3 Experiment 6

4.3.1 Method

Participants: Participants who took part in Experiment 5 also participated in Experiment 6. The experiment received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Design, Materials and Procedure: Experiment 6 used the same design and materials as Experiment 5. The procedure was also the same apart from the modification of the inter-stimulus interval. In order to explore hemispheric differences during pun processing and decomposition effects in the two hemispheres at a later stage of processing, the lateralised target was presented with a delay of 750ms (ISI: 750ms).

4.3.2 Results

Non-experimental stimuli (all filler sentences followed by non-words) were removed from the analyses. Prior to statistical analyses, errors (6.3%) and outliers (3.9%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Decomposition: decomposable idioms, non-decomposable idioms) x 2(Context: idiomatic, double-meaning consistent) x 3(Target type: idiomatic-related, literal-related and unrelated) x 2(Visual Field: left visual field, right visual field) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls ($p<.05$) post-hoc tests.

Response Latencies:

The Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiomatic, double-meaning consistent) x Target type (idiom-related, literal-related and unrelated) x Visual Field (left visual field, right visual field) ANOVA carried out with reaction time (RT) data revealed significant main effects of Target type (by subjects) [*F1*(2,38) = 13.027, MS = 7424, *p*<0.0001, η_p^2 = 0.407; *F*2(2,58) = 2.00, MS = 46003, *p*=0.144, η_p^2 = 0.065], and Visual Field [*F*1(1,19) = 17.276, MS = 32647, *p*<0.0005, η_p^2 = 0.476; *F*2(1,29) = 63.16, MS = 46003, *p*<0.0001, η_p^2 = 0.685]. Additionally, there were significant two-way interactions of Decomposition and Context (by subjects) [*F*1(1,19) = 4.555, MS = 2369, *p*<0.046, η_p^2 = 0.193; *F*2(1,29) = 2.25, MS = 2587, *p*=0.145, η_p^2 = 0.072], Decomposition and Target type [*F*1(2,38) = 17.388, MS = 18504, *p*<0.0001, η_p^2 = 0.478; *F*2(2,58) = 4.75, MS = 28173, *p*<0.012, η_p^2 = 0.141] as well as Target type and Visual Field [*F*1(2,38) = 5.445, MS = 3249, *p*<0.008, η_p^2 = 0.223; *F*2(2,58) = 4.33, MS=5940, *p*<0.018, η_p^2=0.130]. The data also revealed significant three three-way interactions of Decomposition, Context and Visual Field [*F*1(1,19) = 24.327, MS = 11659, *p*<0.0001, η_p^2 = 0.561; *F*2(1,29) = 10.05, MS = 15696, *p*<0.003, η_p^2 = 0.257], Decomposition, Target type and Visual Field [*F*1(2,38) = 3.785, MS = 3912, *p*<0.032, η_p^2 = 0.166; *F*2(2,58) = 4.90, MS = 7166, *p*<0.01, η_p^2 = 0.144], and Context, Target type and Visual Field [*F1*(2,38) = 4.817, MS = 3084, *p*<0.013, η_p^2 = 0.202; *F*2(2,58) = 3.01, MS = 3918, *p*<0.057, η_p^2 = 0.094].

Post-hoc tests to investigate further the significant main effect of Target type revealed that only literal target (605ms) were faster than unrelated targets (616ms, *p*<0.0001) while idiomatic targets (616ms) did not differ from unrelated ones (*p*=0.961). Post-hoc tests to explore the significant effect of Visual Field revealed that, consistent with the common finding that the LH is dominant for language processing, responses made in the right visual field-LH (604ms) were significantly faster than responses made in the left visual field-RH (621ms, *p*<0.0006).

Post-hoc tests to explore further the significant interaction of Decomposition and Context did not reveal any additional significant differences. Post-hoc tests that investigated the interaction of Decomposition and Target type revealed the following patterns. For decomposable idioms, although responses to literal targets (599ms) were similar to unrelated

targets (610ms; p=0.09), responses to idiomatic targets (629ms) were significantly slower than unrelated targets (p<0.004) indicating that during the later stages of processing the literal meanings of decomposable idioms showed signs of decaying (relative to their strong priming effects found in Experiment 5) while the idiomatic meanings still showed interference effects. For non-decomposable idioms, responses both for idiomatic (604ms) and literal targets (611ms) showed robust priming effects relative to unrelated targets (623ms; p<0.004 and p<0.02 respectively) indicating that even during the later processing stages non-decomposable idioms exhibited a parallel pattern of activation for the literal and idiomatic meanings.

Post-hoc tests to investigate further the significant interaction of Target type and Visual field revealed that in the LH, responses to literal meanings (592ms) showed robust priming effects relative to unrelated targets (613ms; p<0.0001) while responses to idiomatic targets (607ms) were not different from unrelated targets (p=0.146). Conversely, in the RH neither responses to literal (617ms) nor to idiomatic targets (626ms) were statistically different from unrelated targets (613ms; p=0.461 and p=0.129 respectively) suggesting that while the LH showed a strong preference for processing literal meanings, the RH treated both literal and idiomatic as unrelated to the prime.

Post-hoc tests to explore further the significant three-way interaction of Decomposition, Context and Visual Field revealed the same effects as those obtained for automatic processing in Experiment 5. In particular, decomposable idioms in single-meaning idiomatic contexts were processed significantly faster by the LH (596ms) than by the RH (624ms, p<0.0002) indicating a LH advantage. However, decomposable idioms in punning double meaning consistent contexts were processed equally fast by the two hemispheres (LH: 613ms, RH: 616ms, p=0.562) indicating a more bilateral processing for decomposable puns. On the other hand, non-decomposable idioms in single meaning idiomatic contexts were processed equally fast by the two hemispheres (LH: 610ms, RH: 621ms, p=0.06), whereas non-decomposable idioms in punning double-meaning consistent contexts were processed significantly faster by the LH (577ms) than the RH (606ms, p<0.0002). Thus, the data suggested that the bilateral processing of decomposable puns, and the LH preference for the processing of non-decomposable puns observed in Experiment 5 was preserved in Experiment 6 (see Figure 13).

Post-hoc tests to explore further the significant interaction of Decomposition, Target type and Visual Field revealed the following hemispheric asymmetries. For decomposable idioms, in the LH, idiomatic (616ms) and literal targets (592ms) were not statistically different from unrelated targets (605ms; p=0.326 and p=0.397 respectively) while literal targets were significantly faster

than idiomatic ones (p<0.03). In the RH, literal targets (605ms) did not differ from unrelated ones (614ms, p=0.541), whereas idiomatic targets (641ms) were significantly slower than unrelated targets (p<0.007). On the other hand, for non-decomposable idioms, in the LH, responses both to idiomatic (598ms) and literal targets (592ms) showed strong priming effects relative to unrelated targets (621ms; p<0.042 and p<0.008 respectively). In the RH, both idiomatic (610ms) and literal targets (629ms) were similar to unrelated ones (625ms; p=0.257 and p=0.589 respectively) indicating a LH advantage for the processing of non-decomposable idioms (see Figure 14). Overall, the data indicates that the LH activated only the literal meanings of decomposable idioms but both literal and idiomatic meanings in parallel for non-decomposable ones. On the other hand, the RH was involved in the processing of idiomatic meanings for decomposable idioms.

Lastly, post-hoc tests to investigate further the significant interaction of Context, Target type and Visual Field revealed the following hemispheric differences. For idiomatic contexts, in the LH, idiomatic (602ms) and literal targets (597ms) did not differ from unrelated targets (608ms; p=0.298 and p=0.11 respectively). Similarly, in the RH, there were no differences among idiomatic (625ms), literal (615ms) and unrelated targets (627ms; p=0.957 and p=0.347 respectively). In contrast, for double-meaning punning contexts, in the LH, responses to literal targets (588ms) were significantly faster than unrelated targets (618ms; p<0.0002) whereas idiomatic targets (612ms) were not different from unrelated ones (p=0.768). In the RH, both responses to idiomatic (626ms) and literal targets (618ms) did not differ from unrelated targets (613ms; p=0.183 and p=0.744 respectively) (see Figure 15). Thus, no hemisphere showed any preference for either the idiomatic or the literal meanings in the idiomatic context, while the LH showed a strong preference only for the literal meanings in punning contexts, pointing again to a LH advantage in pun processing. Mean reaction times for all experimental conditions in Experiment 6 are shown in Table 14. Additionally, Table 15 presents all the significant main and interaction effects from Experiment 6 in comparison to the main and interaction effects observed in Experiment 2 in which we used semantic priming with central presentation for the targets.

Table 14 Mean RTs (ms) for all conditions in Experiment 6. Standard deviations are indicated in parentheses.

Decomposition	**Decomposable idioms**				**Non-decomposable idioms**			
Context	**Single-meaning/Idiom**		**Double-meaning/Pun**		**Single-meaning/Idiom**		**Double-meaning/Pun**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Target Idiomatic	640 (90)	604 (94)	644 (89)	630 (95)	608 (77)	604 (82)	613 (81)	598 (94)
Target Literal	608 (82)	591 (91)	605 (86)	597 (93)	625 (84)	604 (86)	634 (90)	581 (79)
Target Unrelated	627 (75)	596 (89)	603 (83)	618 (100)	628 (76)	624 (86)	625 (83)	620 (98)

Table 15 Significant main and interaction effects from Experiment 2 (late processing of idiomatic puns with central presentation for the targets) and Experiment 6 (late processing of idiomatic puns with lateralised presentation for the targets).

	Main and interaction effects	**Degrees of freedom**	***F* value**	**MS**	***P***	η_p^2
Experiment 2	**Target type**	2,38	14.811	6734	0.001	0.438
	Context	1,19	5.256	2091	0.033	0.217
	Decomposition x Target type	2,38	5.33	1838	0.01	0.219
Experiment 6	**Target type**	2,38	13.027	7424	0.0001	0.407
	Visual Field	1,19	17.276	32647	0.0005	0.476
	Decomposition X Context	1,19	4.555	2369	0.046	0.193
	Decomposition X Target type	2,38	17.388	18504	0.0001	0.478
	Target type X Visual Field	2,38	5.445	3249	0.008	0.223
	Decomposition X Context X Visual Field	1,19	24.327	11659	0.0001	0.561
	Decomposition X Target type and Visual Field	2,38	3.785	3912	0.032	0.166
	Context X Target type X Visual Field	2,38	4.817	3084	0.013	0.202

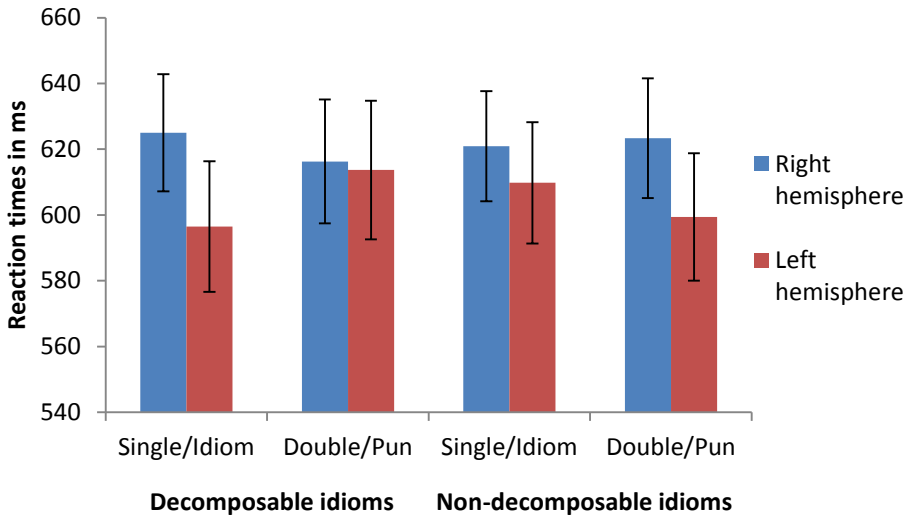

Figure 13 Mean RTs (ms) for decomposable and non-decomposable idioms in single-meaning idiom contexts and double-meaning pun contexts in the two hemispheres. Error bars indicate the standard error of the mean per condition.

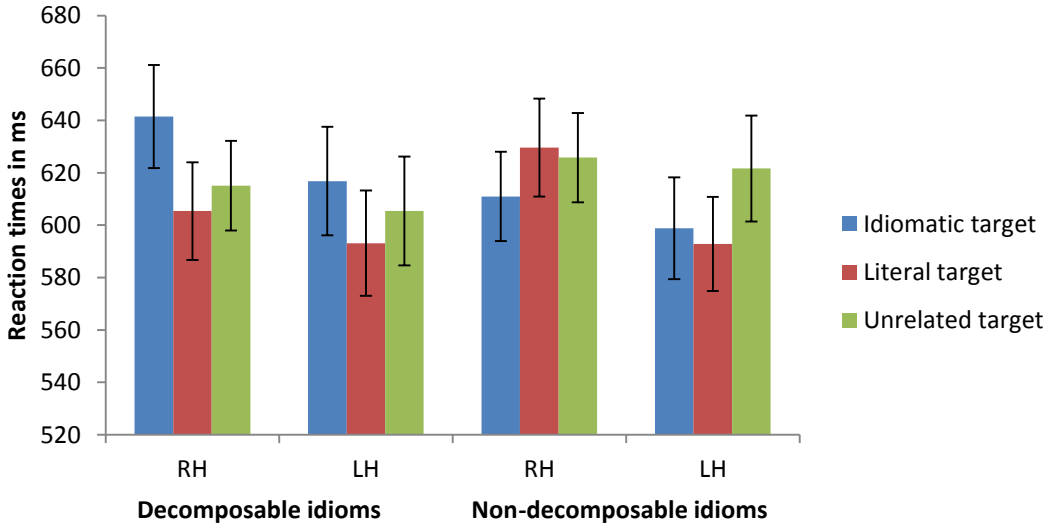

Figure 14 Mean RTs (ms) for the idiomatic, the literal and the unrelated targets for decomposable and non-decomposable idioms in the two hemispheres. Error bars indicate the standard error of the mean.

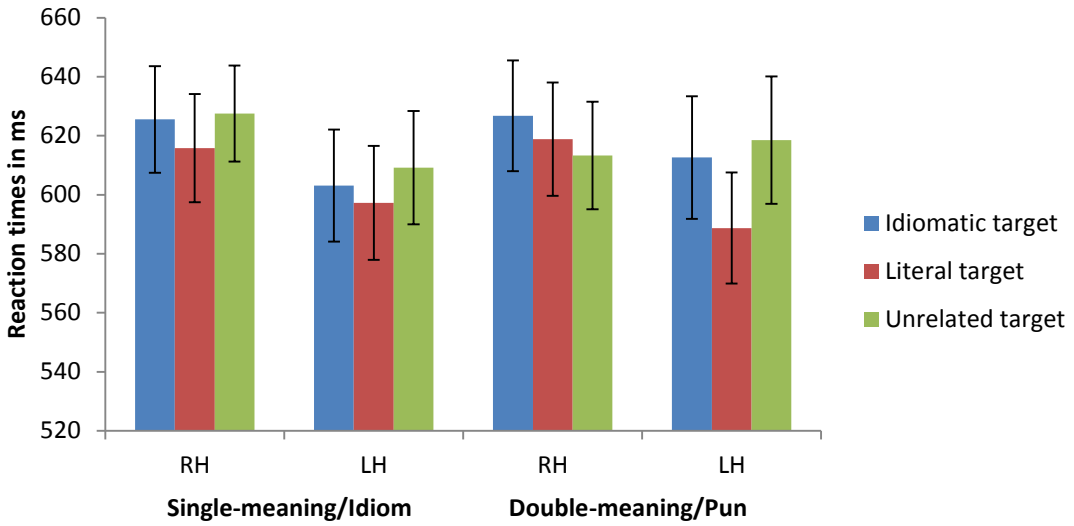

Figure 15 Mean RTs (ms) for the idiomatic, the literal and the unrelated targets for single-meaning idiom contexts and double-meaning pun contexts in the two hemispheres. Error bars indicate the standard error of the mean.

Accuracy rates:

The Decomposition (decomposable idioms, non-decomposable idioms) x Context (idiomatic, double-meaning consistent) x Target type (idiom-related, literal-related and unrelated) x Visual Field (left visual field, right visual field) ANOVA carried out with accuracy (ACC) data revealed only a significant two-way interaction of Decomposition and Target type [$F1(2,38) = 7.72790$, MS = 12.915, $p<0.001$, $\eta_p^2 = 0.289$; $F2(2,58) = 3.09945$, MS = 8.610, $p<0.05$, $\eta_p^2 = 0.097$].

Post-hoc tests to explore it further revealed the following patterns. For decomposable idioms, error rates for both idiomatic (2.2%) and literal targets (1.53%) did not differ from unrelated targets (1.93%; $p=0.206$ and $p=0.222$ respectively). However, errors rates for literal targets were significantly lower relative to idiomatic targets ($p<0.02$) indicating that literal meanings received relatively more priming than idiomatic meanings. For non-decomposable idioms, however, error rates for idiomatic targets (1.57%) were significantly lower compared to unrelated targets (2.25%, $p<0.02$) whereas literal (1.93%) and unrelated targets did not differ from each other ($p=0.430$) indicating that, in contrast to decomposable idioms, for non-decomposable idioms, idiomatic meanings seem to take precedence over literal ones. Percentage of error rates for all conditions in Experiment 6 is shown in Table 16.

Table 16 Percentage of errors for all conditions in Experiment 6.

Decomposition	**Decomposable idioms**				**Non-decomposable idioms**			
Context	**Single-meaning/Idiom**		**Double-meaning/Pun**		**Single-meaning/Idiom**		**Double-meaning/Pun**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Target Idiomatic	2.25%	1.80%	2.65%	2.10%	1.45%	1.60%	1.55%	1.70%
Target Literal	1.70%	1.35%	1.45%	1.65%	2.05%	1.70%	2.00%	2.00%
Target Unrelated	1.95%	1.95%	1.65%	2.20%	2.35%	2.05%	2.05%	2.55%

4.3.3 Discussion

Overall, the pattern of results obtained from Experiment 6 indicates that the degree of idiom decomposition continues to play an important role during the later stages of idiom processing. In particular, the results suggest that processing non-decomposable idioms in idiomatic contexts leads to a processing advantage relative to processing decomposable idioms in the same contexts. However, most importantly the results point to the conclusion that non-decomposable idioms in punning contexts engage the LH, whereas decomposable idioms in punning contexts recruit both hemispheres (i.e., decomposable idioms in double-meaning consistent sentences required additional processing from the RH).

4.4 General Discussion

The present study aimed to expand our knowledge of decomposition effects for idioms used in context as well as to investigate hemispheric asymmetries for processing double-meaning consistent contexts (i.e., puns) that were motivated by decomposable and non-decomposable idioms (henceforth decomposable and non-decomposable puns). It comprised of two hemi-field semantic priming experiments that explored the time-course of meaning activation for idioms used in context in the two hemispheres. Experiment 5 employed a short ISI (0ms) to tap onto the early stages of meaning access, while Experiment 6 employed a long ISI (750ms) to target the later stage of attention-driven processing. Consistent with the results from the behavioural study discussed in Chapter 2 (Experiments 1 and 2), the current data indicated decomposition effects in idiomatic single-meaning consistent contexts suggesting that non-

decomposable idioms show a processing advantage over decomposable idioms. In particular, across the two ISIs, only idiomatic meanings for non-decomposable idioms showed strong priming effects relative to unrelated baseline targets, whereas the idiomatic meanings of decomposable idioms were processed slower than the unrelated baseline targets. Additionally, the current study also pointed to decomposition effects in punning double-meaning consistent contexts justifying further the psychological reality of decomposable and non-decomposable puns. Most importantly, however, the decomposition effects in punning contexts were further modulated by the hemisphere that was initially involved for their processing. Partially consistent with our hypothesis decomposable puns required bilateral processing, indicating RH contributions. On the other hand, and consistent with the experimental literature on pun processing so far (Coulson and Severens, 2007; Kana and Wandsworth, 2012), non-decomposable puns showed mostly LH involvement. Such hemispheric differences for decomposable and non-decomposable puns were observed both in Experiment 5 (ISI: 0ms) and Experiment 6 (ISI: 750ms) indicating that they were not a function of only early or late processing, but instead these hemispheric effects start at the earliest stages of processing and persist. It is argued that the cerebral asymmetries between decomposable and non-decomposable puns could be attributed to representational differences between the two types of idioms making decomposable puns harder to process, leading to RH recruitment.

Decomposition effects in single-meaning idiomatic and double-meaning punning contexts

Consistent with the behavioural data discussed in Chapter 2, the current study further attests that it was non-decomposable idioms that showed a processing advantage over decomposable idioms in single-meaning consistent contexts. In addition, as the present study used the more sensitive divided visual fields paradigm, it revealed a more detailed picture of how processing decomposable and non-decomposable idioms in idiomatic contexts differ from each other. In particular, decomposition effects in idiomatic single meaning contexts were evident both during early and late processing. Across the two ISIs both literal and idiomatic meanings of non-decomposable idioms were processed successfully in a parallel manner, whereas it was only the literal meanings of decomposable idioms that showed successful processing. The idiomatic meanings of decomposable idioms exhibited strong and consistent interference effects. As it was discussed in Chapter 2, such pattern of results supports the hybrid model of idiom representation according to which access to the idiomatic meaning is achieved via access to the literal meanings of the component words (Cutting and Bock, 1997). Furthermore, consistent with findings discussed by Cieslicka (2013) and Titone and Connine (1999) the

current results argue that only the idiomatic meanings of non-decomposable idioms have a separate representation in the mental lexicon, whereas the idiomatic meanings of decomposable idioms are possibly computed on-line on the basis of extending their literal meanings. Thus, the processing advantage of non-decomposable idioms over decomposable ones could be explained by the assumption that retrieving a lexicalised idiomatic meaning from the mental lexicon is a faster and relatively less costly process than inferentially arriving at a non-lexicalised meaning possibly following rule-based pragmatic processing.

Furthermore, the current study showed robust decomposition effects for idioms used in double-meaning consistent punning contexts suggesting that decomposable puns follow a different processing pattern from non-decomposable puns. It is claimed here that differential processing between decomposable and non-decomposable puns could possibly be the result of the lexicalized status of the idiomatic meanings of non-decomposable idioms, and the inferentially derived idiomatic meaning of decomposable idioms. There was evidence in the data suggesting that after non-decomposable puns neither literal nor idiomatic meanings were initially activated relative to a baseline, whereas by 750ms both meanings showed robust priming effects. After decomposable puns, it was only the literal meanings that showed priming effects, while the idiomatic ones were treated as unrelated. It is worth mentioning that the punning context for decomposable idioms successfully resolved the interference effects caused by the idiomatic meanings in single-meaning non-punning contexts. Thus it seems likely that initially the punning context for non-decomposable idioms creates a favourable environment for competition effects between two lexicalised concepts, namely the literal and the idiomatic meanings. On the other hand, such competition effects were not evident for the same context for decomposable idioms possibly due to two inter-related reasons: (i) the non-lexicalised idiomatic meaning being closely related to the literal one and (ii) the focus of the punning contexts on the literal meanings of idiomatic expressions. Both assumptions are pointing to the conclusion that the punning contexts in this case would make the literal meaning seem as the only relevant one. Thus, we are lead to assume that the punning double-meaning consistent context creates a situation for competition between the two meanings of non-decomposable idioms, which translates in no activation for either the literal or the idiomatic meanings. In contrast, a similar punning context results in no obvious competition between the two meanings of decomposable idioms, which translates in activation only for the literal meanings and no interference from the idiomatic ones.

It is conceivable that the different pattern of meaning activation for the two types of idioms in the two contexts is a consequence of a lexical selection mechanism based on competition processes that have been observed in similar cases in behavioural experiments (e.g., Caramazza and Costa, 2000; Costa, Alario and Caramazza, 2005; Finkbeiner and Caramazza, 2006). More specifically, we argue that for non-decomposable idioms, the strong and consistent semantic facilitation for the idiomatic meanings in idiomatic contexts is a result of priming in the absence of any competition effects occurring between the distantly related literal and idiomatic meanings for this type of idioms. The literal meanings are activated by default as they are the immediate constituents of idioms but they do not compete with the idiomatic meanings as they are too distantly related to be considered relevant. The punning context changes the situation dramatically by forcefully making the literal meanings seem equally relevant as the idiomatic meanings, thus we observe competition between the two meanings in an attempt for one of them to be selected. Conversely, the strong interference observed for the idiomatic meanings of decomposable idioms in idiomatic contexts is a result of the fierce competition effects from the closely related literal meanings of these idioms, i.e., both literal and idiomatic meanings are perceived to be equally relevant to be selected in the idiomatic context. According to the behavioural measurements in the current study, the punning context changes the situation only slightly in this case. Since the punning context relies on the literal re-interpretation of the idiom, and we already know that (i) the literal meanings of decomposable idioms are highly activated in the idiomatic single-meaning context, and (ii) the literal meanings are closely related to the idiomatic ones, in the punning context responses capture predominantly the literal meaning. The result is that the literal meaning is considered the most relevant one while the idiomatic meaning gets a chance to improve slightly and not show semantic interference effects. Thus, overall, it is likely that contexts in which two meanings are equally 'response relevant' will lead to competition effects (non-decomposable puns and decomposable idioms), whereas contexts in which the two meanings are related but not considered equally 'response relevant' will produce facilitation effects (non-decomposable idioms and decomposable puns).

Support for this claim comes from research investigating the well-attested semantic interference effect during a picture-word naming task (Caramazza and Costa, 2000; Costa et al., 2005; Finkbeiner and Caramazza, 2006). In a picture-word naming task participants are asked to name a picture as quickly as possible while ignoring a distractor word shown on the picture. Even though it is common to find that (i) naming a picture takes longer when a distractor word is present relative to situations without distractors and (ii) naming a picture

takes even longer when the distractor is semantically related to the picture (the semantic interference effect), Finkbeiner and Caramazza (2006) argue that a semantic interference effect is not always the expected result. There are occasions when a semantically related distractor may lead to *faster* naming instead, i.e. semantic facilitation. In an attempt to uncover the conditions that would cause semantic interference or semantic facilitation, Finkbeiner and Caramazza (2006) found that a semantic interference effect is only observed when the distractor word is closely related to the picture. Conversely, when the distractor word is more distantly related to the picture, the results point to a semantic facilitation effect. For example, with a picture of a car and a distractor word *bumper* the results point to semantic facilitation; when, however, the distractor word is *truck* the results point to semantic interference because *car* and *truck* are more equally relevant as responses compared to *car* and *bumper*. According to Costa et al. (2005), the underlying cause for the semantic interference effect is the fact that *truck* has 'response relevance', or in other words it is so closely related to the picture that it is also considered by the language processor as a potentially appropriate response. Such results from the literature on the picture-word naming task have clear relevance for the results we obtained in the current study. It is argued here that the literal meanings of the two types of idioms behave in a similar way to distractor words in a picture-naming task. In particular, the distant semantic relationship between the literal meaning and the idiomatic meaning of non-decomposable idioms in idiomatic contexts results in semantic facilitation for the idiomatic meaning as the literal one is not considered 'response relevant'. On the other hand, the same two meanings in the double meaning context become equally relevant, thus we observe competition effects. In contrast, the close semantic relationship between the literal and idiomatic meaning of decomposable idioms in idiomatic contexts results in competition and semantic interference for the idiomatic meanings as the literal meaning is considered equally 'response relevant' to the idiomatic ones. In double-meaning consistent punning contexts, behavioural responses may have obscured these interference effects to some extent as the punning contexts for decomposable idioms place extra focus on the literal meanings making them seem as if they were the only response relevant choice, while the idiomatic meanings are treated as unrelated. To sum up, it has been argued here that decomposition effects in idiomatic and punning context could be explained by the close semantic relation between the literal and non-lexicalised idiomatic meanings for decomposable idioms and the distant relationship between the literal and lexicalised idiomatic meanings for non-decomposable idioms.

Decomposition effects and hemispheric differences: implications for puns

The second key point of interest in the present study was to investigate the hemispheric differences in the time-course of meaning activation for decomposable and non-decomposable puns. The results point to the conclusion that across the two ISIs, the LH was responsible for the processing of non-decomposable puns, whereas both hemispheres were equally engaged for the processing of decomposable puns. Thus, the present findings are consistent with our initial hypothesis that carefully controlling for the internal semantics of puns we are more likely to observe RH involvement in the comprehension of puns. The results are only partially consistent with the existent literature of pun processing that argues that puns are mainly processed in the LH (Coulson and Severens, 2007; Goel and Dolan, 2001; Kana and Wadsworth, 2012). Our study extends the published literature on puns by presenting experimental evidence that some puns could also be processed bilaterally, thus recruiting RH neural networks.

It is argued that the overall pattern of cerebral asymmetries for non-decomposable and decomposable puns could be explained by (i) differences in the mental representations of decomposable and non-decomposable idioms motivating the puns and consequently (ii) differences in the degree of conventionality and novelty for the idiomatic meanings of these two types of idioms. More specifically, since the idiomatic meanings of non-decomposable idioms are stipulated in the mental lexicon these meanings are considered conventionalized enough to rely on meaning retrieval. In that case, the LH advantage is evident in non-decomposable puns because the punning contexts require the literal and idiomatic meanings of non-decomposable idioms to be activated and recognised as different. The evidence we have that these two meanings are activated in single meaning idiomatic contexts by default makes non-decomposable puns relatively cost-free to process. Conversely, since the idiomatic meanings of decomposable idioms are very similar to the literal meanings of these idioms it is implied that they are unlikely to be lexicalised in the same way idiomatic meanings of non-decomposable idioms are. Thus, most likely idiomatic meanings of decomposable idioms are not stipulated in the mental lexicon but are derived from their literal meanings, following a pragmatically-oriented inferential processing mechanism. It is conceivable to believe that the inferential step required for these idioms is what makes them harder to process (relative to non-decomposable idioms). According to Vigneau et al (2011) the RH is recruited in processing that proves to be more costly. Thus we claim here that the extra processing cost required for decomposable puns is what partly necessitates the bilateral network for processing

decomposable puns. In other words, the bilateral processing is evident in decomposable puns because the punning contexts require the literal and idiomatic meanings of decomposable idioms to be seen both as similar (which they are by default) and at the same time equally different in order to create the contrastive context of the pun. Thus, holding two distinct meanings in a contradictory punning context as is exemplified by non-decomposable puns seems to be a less costly process than holding two similar meanings in contradictory punning contexts as exemplified by decomposable puns. The extra cost associated with decomposable puns is most likely related to processing the idiomatic meanings of those idioms. Recall that across both ISIs in idiomatic contexts decomposable idioms exhibited strong and persistent interference effects. Since the RH is expected to be engaged in processing that is relatively more demanding (Vigneau et al., 2011), then it is not surprising that decomposable puns would be processed bilaterally.

Further evidence for this assumption comes both from the current data set and the cognitive continuum hypothesis suggested by Faust and Kenett (2014). Recall from the results section that the idiomatic meanings of decomposable idioms in single meaning idiomatic contexts were harder to process and exhibited interference effects, i.e. they showed slower reaction times than unrelated meanings when processed in the RH (and they did not show activation in the LH). There are two forces that may have caused the interference to be evident in the RH. Firstly, this finding is consistent with the fine-coarse coding hypothesis according to which semantic representations in the RH are more diffuse and less clear-cut (e.g., Jung-Beeman, 2005). In other words, the RH is less adept to tightly focus on intended meanings and it is pre-disposed to spreading activation farther than the LH. Additionally, the idiomatic meanings of decomposable idioms are processed as derivative from the literal ones, i.e., they are inferential in nature pointing to the prediction that they will be harder to activate relative to meanings that rely on meaning retrieval only. Therefore, it is reasonable to assume that the idiomatic meanings of decomposable idioms will engage the RH network as they are non-lexicalized and thus less conventional, which also makes them harder to process. The punning context seems to perpetuate the complications in the case of decomposable idioms as it results in a sentence in which the inferentially derived idiomatic meaning has to be seen as similar to the literal meaning from which it is derived but at the same time sufficiently different from it for the pun to work. Thus, the overall claim is that processing decomposable puns requires an additional step, namely the on-line computation of the idiomatic meanings of decomposable idioms, which is not needed for the idiomatic meanings of non-decomposable idioms that motivate non-decomposable puns. The extra effort required for the computation process engages to

some extent the RH for additional support. To sum up, the two intended but related meanings in the decomposable puns were processed bilaterally as deriving the idiomatic meaning from the literal meaning of decomposable idioms and holding the two related yet appearing as distinct meanings in the pun requires greater effort.

Such patterns of results that show LH processing for non-decomposable puns and bilateral processing for decomposable puns are consistent with the recent suggestion of the existence of a cognitive continuum for experimentation on non-literal language processing (Faust and Kenett, 2014). In particular, Faust and Kenett (2014) argue that the conflicting data in the experimental literature on non-literal language processing, mainly metaphor processing, could be explained by individual differences in the linguistic nature of non-literal language. At one end of the scale, Faust and Kenett (2014) place evidence suggesting LH processing for non-literal language that is rather conventional in nature (e.g., Stringaris et al., 2007). At the other end of the scale, the researchers place evidence that suggests RH processing for non-literal language that is considered more novel and original (e.g., Faust and Mashal, 2007). Within this framework, bilateral processing for non-literal language is evidenced in cases in which both hemispheres are required for semantic processing. Faust and Kenett (2014) argue that RH processing could be characterised as *chaotic* because of this hemisphere's flexibility and ability to activate larger semantic fields, while LH processing is defined as *rigid* because LH processing relies on strictly defined and stipulated rules. Therefore, in order to relate back to the findings of our study, we suggest that processing non-decomposable puns only recruits the LH resources because both literal and idiomatic meanings of non-decomposable idioms are conventional and coded in the mental lexicon. In contrast, processing decomposable puns departs from LH processing and requires additional processing from the RH too because the idiomatic meanings of decomposable idioms are not conventionalised and coded in the mental lexicon but rather derived from the literal meanings.

4.5 Conclusions

In summary, the present study provides experimental evidence in support of the hypothesis that the internal semantics of puns is an important variable to be taken into consideration for research investigating hemispheric asymmetries in pun comprehension. By carefully controlling for the internal motivating structure of puns the study extends further the existing literature on pun processing by investigating the cerebral asymmetries for non-decomposable and decomposable puns. Consistent with our predictions, the underlying linguistic nature of the pun led to important hemispheric differences. In particular, consistent with the

experimental literature on pun processing, non-decomposable puns exhibited LH processing advantage (Coulson and Severens, 2007; Goel and Dolan, 2001; Kana and Wadsworth, 2012). In contrast, decomposable puns, which required greater processing resources, partially recruited resources from the RH as well as the LH, i.e., decomposable puns exhibited bilateral processing. Such results are consistent with the cognitive continuum hypothesis for non-literal language processing (Faust and Kenett, 2014) that argues that differential hemispheric processing for non-literal language is predicted on the basis of the linguistic nature motivating the non-literal language. Thus, the present results extend the existing literature on pun processing which claimed that puns were processed exclusively in the LH (e.g., Coulson and Severens, 2007; Kana and Wadsworth, 2012) by providing experimental evidence that some puns, namely decomposable puns, require bilateral processing.

In section 3.6 the processing and representational similarities between decomposable idioms and polysemous words on the one hand, and non-decomposable idioms and homonymous words on the other were suggested and briefly summarised. On the basis of these similarities we designed a second divided visual field semantic priming study aiming to investigate cerebral asymmetries during the processing of puns motivated by polysemous and homonymous words. The overall aim of the study presented in the next chapter is to explore further the hemispheric asymmetries associated with pun processing and how the internal semantics of puns may affect processing. If the similarities that were observed in Section 3.6 between idioms and ambiguous words are true, then we would expect polysemous puns to exhibit bilateral processing and homonymous puns to exhibit mostly LH processing.

Chapter 5. Cerebral asymmetries for processing puns motivated by ambiguous words

5.1 Introduction

The previous chapter provided experimental evidence in support of the hypothesis that some puns benefit from recruiting additional processing resources from the right hemisphere, namely puns that are motivated by decomposable idioms. The current chapter continues to investigate the hemispheric asymmetries during pun processing and the importance of the internal semantics of puns in that process by focusing on puns that are motivated by homonymous and polysemous ambiguous words.

Research investigating the processing of lexical ambiguity in the cerebral hemispheres strongly suggests that the right hemisphere is implicated in the process of meaning activation for ambiguous words (i.e., words that have more than one meaning). For example, Burgess and Simpson (1988) reported that in a lexical decision task conducted in a half-field semantic priming paradigm during automatic processing (SOA: 35ms) the left hemisphere was involved in the activation of both dominant and subordinate meanings of ambiguous words, while only dominant ones were activated in the right hemisphere. On the contrary, during the later stages of processing (SOA: 750ms) the LH was involved in the activation only of dominant meanings, whereas the RH activated both dominant and subordinate meanings. Burgess and Simpson (1988) argued that the two hemispheres showed differential processing for the alternative meanings of ambiguous words that was affected by meaning dominance and the timing of stimulus presentation. More specifically, they claimed that subordinate meanings show a slower rise in the RH making them available only during the later stages of meaning processing. Although Burgess and Simpson (1988) reported bilateral activation for the dominant meanings of ambiguous words during automatic processing (SOA: 35ms), research that considered the semantic relationship between primes and targets reported stronger priming in the RH relative to the LH during automatic processing (Chiarello, 1985; Chiarello et al., 1992; Chiarello and Richards, 1992). For example, in a lexical decision half-field study Chiarello and Richards (1992) aimed to investigate categorical priming in the two hemispheres during automatic processing. They presented participants with laterally displayed prime-target pairs that were related only through category membership and were not associatively related (e.g., LEG-HAND or TULIP-POPPY). The results indicated highly reliable priming effects in the RH and no significant effects in the LH. Chiarello and Richards (1992) argued that the results support a view of hemispheric processing in which the right hemisphere initially activates a

broader semantic field than the left hemisphere. Even though the study employed laterally presented stimuli, the results obtained from this line of research clearly suggest that different semantic relationships between primes and targets could employ the hemispheres differentially during ambiguity resolution.

The hemispheric differences reported both by Burgess and Simpson (1988) and Chiarello and Richards (1992) concerned the study of ambiguous words in isolation, which raises the issue of whether such hemispheric differences hold when ambiguous words are used in context. The results from the literature exploring hemispheric sensitivity to sentential context, however, are varied and not highly consistent. On the one hand, some researchers indicate that the RH exhibits little sensitivity to context and meaning that is derived from the syntactic organisation of the sentence (e.g., Faust et al., 1995; Faust, 1998). For example, Faust (1998) reviewed research she had conducted suggesting that any priming effects that are observable in the RH result from intra-lexical associations between laterally presented target words and words that are used in priming sentences. On the other hand, behavioural experiments (Coney and Evans, 2000; Peleg and Eviatar, 2008) and electrophysiological investigations (Federmeier, Mai and Kutas, 2005; Federmeier and Kutas, 1999) provided evidence in support of the claim that the RH is indeed sensitive to sentential context. In particular, Peleg and Eviatar (2008) investigated contexts effects in the two hemispheres during automatic processing in a lexical decision half-field priming study. The results indicated that in dominant-meaning consistent sentences only the dominant, contextually appropriate meanings were bilaterally activated. Furthermore, in subordinate-meaning consistent sentences there was bilateral activation for both the dominant and subordinate meanings. Peleg and Eviatar (2008) argued that both hemispheres show sensitivity to contextual effects and meaning dominance even though the LH is possibly more sensitive to lexical features such as meaning dominance. Lastly, Titone (1998) suggested that there are occasions in which the RH may be even more sensitive to sentential context than the LH. In particular, in Experiment 3, Titone (1998) asked participants to listen to ambiguous homonyms that were used in sentential context biasing a peripheral feature of the subordinate meaning of that homonym. Lexical decisions to targets were made at the offset of the homonym; targets were laterally presented and they were either related to the dominant or the subordinate meaning of the homonym. The results indicated that the dominant meanings were activated in the LH, while the subordinate meanings were only activated in the RH. Therefore, Titone (1998) argued that the LH is insensitive to the peripheral aspects of the subordinate meanings while the RH shows sensitivity to these meanings. In summary, then, the literature on context effects for ambiguous words processed in the two hemispheres

provides evidence that the RH may be preferentially involved during the very early stages of language processing if the context biases a subordinate meaning or a peripheral feature of a subordinate meaning. Overall, therefore, if ambiguous words were employed in double-meaning consistent contexts (or, puns), it is reasonable to expect RH involvement as well since very often the dual nature of puns relies on activating and maintaining subordinate meanings and even peripheral features of subordinate meanings.

However, as we discussed in Chapter 1, the research on lexical ambiguity resolution has mainly been built on the implicit understanding that lexical ambiguity is a homogeneous linguistic phenomenon. Yet, theoretical semantics convincingly argues in favour of fine distinctions within lexical ambiguity (Lyons, 1977; Cruse, 1986). The two main subtypes of primary importance for this thesis are the distinctions between homonymous and polysemous words (refer to Section 1.1.4 for a detailed description of sense-relatedness effects). In addition to processing differences between polysemous and homonymous words when they are used in isolation, Section 1.2.3 from the Literature Review presents further evidence that the two types of ambiguous words are processed differentially by the two hemispheres. In particular, Klepousniotou et al (2012) published electrophysiological data revealing that while the LH showed better processing of the subordinate meanings of homonyms, the RH showed a processing advantage for the subordinate senses of polysemous words. Even though to date there is no investigation that explores hemispheric asymmetries for polysemous and homonymous ambiguous words used in sentential contexts, on the basis of evidence of sense-relatedness effects in sentence contexts (Chapter 3 of this thesis), hemispheric differences for polysemous and homonymous words used in isolation (Klepousniotou et al., 2012) and RH sensitivity to different sentence contexts (e.g., Titone, 1998) we might expect hemispheric differences for polysemous and homonymous words used in dominant consistent, subordinate consistent and double-meaning consistent sentences (or puns).

Therefore, the present study was designed to investigate hemispheric differences in the time-course of double meaning activation for puns motivated by polysemous and homonymous ambiguous words. Two half-field cross-modal priming lexical decision experiments were carried out in which participants listened to sentences that ended either in a polysemous or homonymous ambiguous word when it was (i) used in its dominant meaning (dominant consistent sentences, or dominant sentences), (ii) used in its subordinate meaning (subordinate consistent sentences, or subordinate sentences) or (iii) used in a way in which both dominant and subordinate meanings were intended as equally consistent (double-

meaning consistent sentences, or puns). Each sentence was followed by the visual lateralized presentation of a related word or non-word for which a lexical decision had to be made. Target words were either related to the dominant meanings (dominant targets), the subordinate meanings (subordinate targets) or were unrelated. In Experiment 7, the target words were presented immediately at the end of the sentence (ISI: 0ms) in order to investigate automatic processing. In Experiment 8, the presentation of the targets was delayed; they were presented 750ms after the end of the sentence to tap the later stages of language processing. Consistent with the earlier behavioural investigation on processing puns motivated by polysemous and homonymous words (Chapter 3: Experiments 3 and 4) it is expected that the current study will replicate the sense-relatedness effects for ambiguous words used in context. Based on the hemispheric differences for polysemous and homonymous words reported by Klepousniotou et al. (2012), it is expected that processing polysemous words will show greater involvement of the RH relative to processing homonymous words. Additionally, in Section 3.6 we suggested that processing polysemous words might bear some resemblance to processing decomposable idioms on the basis of a similarity in the mental representations of the subordinate senses of polysemous words and the idiomatic meanings of decomposable idioms. It was further suggested that the non-lexicalised status of these meanings was likely to induce an inferential type of processing in which the subordinate senses of polysemous words and the idiomatic meanings of decomposable idioms were derived inferentially from the dominant senses of polysemous words and the literal meanings of decomposable idioms respectively following rule-based meaning extension processes. In the previous chapter it became evident that decomposable puns exhibited a bilateral pattern of processing across the two ISIs indicating that this type of puns benefitted from RH processing resources both during the early and the late stages of processing. Thus, all existing evidence so far points in the direction that the right hemisphere might be differentially involved in the processing of polysemous puns both during the early stages of processing (Experiment 7: 0ms) and the later stages of processing (Experiment 8: 750ms).

5.2 Experiment 7

5.2.1 Method

Participants:

Twenty one native speakers of English (9 male and 12 female) with an average age of 20.6 years (range 18-35) and an average of 14 years of education (range 13-17) took part in the experiment for remuneration. All participants were right-handed, as assessed according to the

Handedness Inventory by Briggs and Nebes, 1975, with normal or corrected to normal vision and no history of either neurological or language impairments. The experiment received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Design and Materials:

The study had a within-subjects design with four factors: Context, with three levels (dominant consistent, subordinate consistent, double-meaning consistent, i.e., the pun); Lexical Ambiguity, with two levels (homonymy and polysemy) specifying the type of ambiguous words used in each context; Target type, with three levels (dominant-related, subordinate-related and unrelated), specifying the type of meaning facilitated in each context, and Visual Field (left visual field, right visual field) specifying the visual field presentation of the target. The primary dependent measure was response latencies but accuracy rates were also recorded and analysed. We used the same materials as in the earlier study (Experiments 3 and 4) that relied on the cross-modal semantic priming paradigm with central presentation of targets (see Design and Materials in Chapter 3).

Procedure:

Stimuli were counterbalanced over six lists (List A1, A2, B1, B2, C1 and C2) and the items in each list were pseudo-randomised so that no three stimuli of the same type occurred consecutively. Participants had to attend three sessions separated by at least a week in order to complete the experiment and were tested individually in each session. Each session lasted approximately 60 minutes and participants were asked to complete two lists of the stimuli each time. The order of presentation of the stimuli lists was also counterbalanced. The presentation of the stimuli and the recording of the reaction times and error rates were controlled by E-Prime2. Participants were seated in a comfortable position in front of the computer monitor approximately 57cm away from the screen. They received oral instructions that were reinforced in a written form at the very beginning of the experiment. The instructions informed them that they would use headphones to listen to sentences that would be followed by a word presented visually on the computer screen. They were also informed that the word would flash very quickly either to the left-hand side or to the right-hand side of a small cross that remained in the centre of the screen throughout the experiment. Participants were asked to listen carefully to each sentence and decide whether the word that appeared visually at the end was a real word in English or not. They had to indicate their decisions by

clicking the relevant mouse-buttons as quickly and accurately as possible. The experiment began with a practice block consisting of 11 sentences to allow participants to familiarise themselves with the task. Each trial began with the presentation of a fixation cross for 500ms that was presented in the centre of the screen and remained visible throughout the experiment. Participants were instructed and trained to keep their eyes fixated on the cross during the experiment and refrain from moving. Fixation time was followed by the aural presentation of the priming sentence (between 3 and 5 seconds). Immediately at the end of the sentence, with an inter-stimulus interval of 0ms (ISI: 0ms), the target appeared either in the left visual field or the right visual field. Target stimuli were presented on the computer screen for 150ms with 2.0 degrees foveal eccentricity from the fixation cross. As soon as participants responded or at the end of 1700ms if they failed to indicate any decision, the next trial started automatically after a delay of 200ms. The completion of one session consisted of 720 trials spread over the two lists (360 in each one). Half way through each list there was a short in-built break during which participants were instructed to rest their eyes but not leave their seat. At the end of the first list there was a longer break of approximately 10 minutes during which participants could leave their seat and the experimenter prepared the next list. Participants were required to return in a week's time to complete the second session of the experiment, which followed the exact same procedure as the first session. Approximately a week after the second session the participants were required to come back for their third and final session. The second and third sessions also incorporated 720 trials in each one, which resulted in 2160 trials overall for the entire experiment.

5.2.2 Results

Non-experimental stimuli (all filler sentences followed by non-words) were removed from the analyses. Prior to statistical analyses, errors (8.5%) and outliers (4.6%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2 (Lexical Ambiguity: homonymy, polysemy) x 3 (Context: dominant consistent, subordinate consistent, double-meaning consistent, i.e., puns) x 3 (Target type: dominant-related, subordinate-related and unrelated) x 2(Visual Field: left visual field, right visual field) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls ($p<.05$) post-hoc tests.

Response Latencies:

The Lexical Ambiguity (homonymy, polysemy) x Context (dominant consistent, subordinate consistent, double-meaning consistent, i.e., the pun) x Target type (dominant-related, subordinate-related and unrelated) x Visual Field (left visual field, right visual field) ANOVA carried out with reaction time (RT) data revealed a significant main effect of Target type [*F1*(2,40) = 46.393, MS = 26937, *p*<0.001, η_p^2 = 0.699; *F2*(2,58) = 8.35, MS = 44944, *p*<0.001, η_p^2 = 0.224] and Visual Field [*F1*(1,20) = 5.085, MS = 58610, *p*< 0.036, η_p^2 = 0.203; *F2*(1,29) = 118.35, MS = 74169, *p*<0.001, η_p^2 = 0.803]. Moreover, there were significant two-way interactions of Lexical Ambiguity and Context (by subjects) [*F1*(2,40) = 4.590, MS = 1968, *p*<0.016, η_p^2 = 0.187; *F2*(2,58) = 2.91, MS = 3435, *p*=0.062, η_p^2 = 0.091], Lexical Ambiguity and Target type (by subjects) [*F1*(2,40) = 10.912, MS = 4710, *p*<0.0001, η_p^2 = 0.353; *F2*(2,58) = 1.20, MS = 7940, *p*=0.307, η_p^2 = 0.040], as well as Context and Target Type [*F1*(4,80) = 6.375, MS = 4111, *p*<0.0001, η_p^2 = 0.242; *F2*(4,116) = 6.60, MS = 7044, *p*<0.0001, η_p^2 = 0.185]. The three-way interaction of Lexical Ambiguity, Context and Target Type also reached significant levels [*F1*(4,80) = 3.166, MS = 1735, *p*<0.018, η_p^2 = 0.137; *F2*(4,116) = 2.63, MS = 2740, *p*<0.038, η_p^2 = 0.083], as did the four-way interaction of Lexical Ambiguity, Context, Target type and Visual Field (by subjects) [*F1*(4,80) = 2.560, MS = 1678, *p*<0.045, η_p^2 = 0.113; *F2*(4, 116) = 1.81, MS = 1632, *p*=0.132, η_p^2 = 0.059].

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant main effect of Target type suggested that only the dominant targets (577ms) showed robust priming effects relative to the unrelated ones (596ms, *p*<0.0001). Post-hoc comparisons investigating further the significant main effects of Visual Field revealed that responses made in the right visual field (LH, 580ms) were significantly faster than responses made in the left visual field (RH: 597ms, *p*<0.036) consistent with the well-documented left hemisphere advantage effect for linguistic stimuli.

Post-hoc comparisons to explore further the significant interaction of Lexical Ambiguity and Context revealed the following pattern. For homonyms, response times to double-meaning consistent sentences (582ms) were significantly faster relative to both dominant consistent sentences (593ms, *p*<0.003) and subordinate consistent sentences (590ms, *p*<0.033). On the other hand, for polysemous words, response times to double-meaning consistent sentences

(598ms) were almost identical to dominant consistent sentences (589ms, p=0.956) and subordinate consistent sentences (588ms, p=0.814). The difference between homonymous double-meaning consistent sentences (582ms) and polysemous double-meaning consistent sentences (598ms) also reached significant levels (p<0.05) indicating that maintaining two closely related senses is more taxing than holding two different meanings simultaneously.

Additionally, post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant interaction of Lexical Ambiguity and Target Type revealed a pattern of meaning activation that is affected by sense/meaning relatedness. On the one hand, for homonyms, reaction times for both the dominant (581ms) and subordinate meanings (589ms) showed robust priming effects relative to the unrelated targets (596ms; p<0.0001 and p<0.017 respectively). Also, consistent with the re-ordered access model, reaction times for the dominant meanings were significantly faster than reaction times for the subordinate ones (p<0.006). Conversely, for polysemous words only reaction times for the dominant meanings (572ms) showed facilitation relative to the unrelated targets (597ms; p<0.0001), possibly indicating that accessing the dominant sense might be enough for processing and comprehending different sentential contexts.

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant interaction of Context and Target type revealed differential context effects as a function of meaning dominance. More specifically, after dominant-consistent sentences, dominant targets (577ms) showed strong priming effects relative to unrelated targets (593ms; p<0.0008). However, subordinate targets (604ms) were significantly slower relative to the unrelated targets (593ms; p<0.036). After subordinate consistent sentences, both dominant (580ms) and subordinate targets (586ms) showed priming effects relative to unrelated targets (602ms; p<0.0001 and p<0.001 respectively). After double-meaning consistent sentences, only dominant targets (574ms) showed facilitation effects relative to unrelated targets (593ms; p<0.0002). Subordinate targets (589ms) did not differ from unrelated targets (p=0.599); so unlike dominant consistent sentences that induced interference effects for subordinate targets, double-meaning consistent contexts did not actively suppress subordinate targets.

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant interaction of Lexical Ambiguity, Context and Target type revealed the following patterns. Firstly, for homonyms in dominant consistent sentences, reaction times both for dominant targets (586ms) and subordinate targets (601ms) were not different from reaction times for the unrelated baseline (592ms, p=0.608 and p=0.451 respectively). For homonyms in

subordinate consistent sentences, both reaction times for the dominant targets (580ms) and reaction times for the subordinate targets (583ms) showed robust priming effects relative to the unrelated targets (608ms, $p<0.0001$ and $p<0.0004$ respectively). Finally, for homonyms in double-meaning consistent sentences, reaction times both for the dominant targets (578ms) and subordinate targets (583ms) were not statistically different from reaction times for the unrelated baseline (587ms, $p=0.675$ and $p=0.865$ respectively). At first glance the double-meaning consistent sentence produces the same activation pattern as the dominant-meaning consistent one, but a difference is observed when we compare the activation levels for the subordinate meanings in the two types of sentential context. Namely, the reaction times for the subordinate meanings in double-meaning consistent sentences are significantly faster than reaction times for the same targets in dominant consistent sentences ($p<0.016$) indicating that double-meaning consistent contexts can successfully bias two intended meanings simultaneously. On the other hand, for polysemous words in dominant consistent sentences, only reaction times for dominant targets (567ms) showed priming effects relative to reaction times for the unrelated targets (594ms, $p<0.0002$); subordinate targets (606ms) were not statistically different from the unrelated ones ($p=0.172$). For polysemous words in subordinate consistent sentences, again only dominant targets (579ms) were faster than the unrelated ones (596ms, $p<0.045$); subordinate targets (589ms) were not statistically different from the unrelated ones ($p=0.684$). Finally, for polysemous words in double-meaning consistent sentences, dominant targets (571ms) were statistically faster than the unrelated ones (600ms, $p<0.0001$) whereas subordinate targets (596ms) were not statistically different form the unrelated baseline ($p=0.758$). Thus, unlike homonymous double-meaning consistent contexts, the polysemous double-meaning consistent contexts failed to activate the two senses simultaneously. Therefore, the overall pattern of activation gleaned from the three-way interaction of Lexical ambiguity, Context, and Target type suggests that meaning dominance and sentence context jointly affect the processing of homonyms, while in the case of polysemous words meaning frequency seems to exert greater influence than contextual bias.

In order to explore further the significant four-way interaction between all independent variables, namely Lexical Ambiguity, Context, Target type and Visual Field, two separate ANOVAs were conducted (one for Homonymy and one for Polysemy) with Context, Target type and Visual field as the independent variables

ANOVA to examine effects for homonymous words

In the ANOVA computed for homonymous words all main effects were significant, Context [*F1*(2,40) = 7.486, MS = 3864, *p*<0.002, η_p^2= 0.272; *F2*(2,58)=6.93, MS=6533, *p*<0.002, η_p^2 =0.193], Target type (by subjects) [*F1*(2,40) = 15.048, MS = 6348, *p*<0.0001, η_p^2= 0.429; *F2*(2,58)=1.42, MS=10588, *p*=0.251, η_p^2=0.047] and Visual Field [*F1*(1,20) = 5.939, MS = 35756, *p*<0.024, η_p^2= 0.229; *F2*(1,29)=45.92, MS=52183, *p*<0.0001, η_p^2=0.613]. Additionally, there were significant two-way interaction effects of Context and Target type [*F1*(4,80) = 4.658, MS = 3457, *p*<0.002, η_p^2= 0.189; *F2*(4,116)=5.36, MS=5819, *p*<0.0005, η_p^2=0.156], and Target type and Visual Field (by subjects) [*F1*(2,40) = 3736, MS = 2108, *p*<0.033, η_p^2= 0.157; *F2*(2,58)=1.46, MS=2345, *p*=0.241, η_p^2=0.048].

Post-hoc comparisons to explore further the main effect of Context revealed that double-meaning consistent sentences (582ms) were processed faster than both dominant (593ms) and subordinate consistent sentences (590ms; *p*<0.002 and *p*<0.008 respectively), which did not differ from each other (*p*=0.341) indicating that holding two different meanings in a contradictory pun context is easier compared to contexts that require processing only one meaning. Post-hoc comparisons to explore further the main effect of Target type revealed that both dominant (581ms) and subordinate targets (589ms) showed robust priming effects relative to unrelated targets (596ms; *p*<0.0001 and *p*<0.016 respectively). Consistent with the re-ordered access model, the dominant meanings showed stronger activation levels relative to the subordinate meanings (*p*<0.005). Finally, post-hoc comparisons that explored the main effect of Visual Field showed that stimuli presented in the right visual field (rvf-LH) were processed significantly faster than stimuli presented in the left visual field (lvf-RH) (*p*<0.024) attesting to the overall LH advantage for processing language.

Post-hoc analysis of the two-way interaction of Context and Target type revealed the following patterns. After dominant consistent sentences, there were no priming effects for dominant (586ms) or subordinate targets (601ms) relative to unrelated targets (592ms; *p*=0.542 and *p*=0.119 respectively). However, the difference between the dominant and subordinate targets reached significant levels (*p*<0.05) indicating that the dominant context primes the dominant meanings. After subordinate consistent sentences, both dominant (580ms) and subordinate targets (583ms) showed strong priming effects in comparison to unrelated targets (608ms; *p*<0.0003 and *p*<0.001 respectively). This result implies that the subordinate-meaning

consistent context can successfully guide access to the subordinate meanings while dominant meanings are activated by default as a function of their meaning dominance/frequency of usage. After double-meaning consistent sentences (or puns) neither dominant (578ms) nor subordinate targets (583ms) were facilitated relative to unrelated targets (587ms; p=0.736 and p=0.909 respectively). In addition, the difference between the dominant and subordinate targets did not reach significance (p=0.753). These findings indicate that double-meaning consistent contexts create conditions for competition effects between the two meanings of the homonym, which were not evident either in dominant-meaning consistent or subordinate-meaning consistent contexts.

Post-hoc comparisons that explored further the interaction effects of Target type and Visual Field revealed that when targets were presented to the right visual field (rvf-LH), both dominant (576ms) and subordinate targets (575ms) showed strong priming effects relative to unrelated targets (586ms; p<0.023 and p<0.044 respectively). In contrast, when targets were presented to the left visual field (lvf-RH) dominant targets (587ms) showed priming relative to the unrelated targets (605ms; p<0.0003), whereas subordinate targets (603ms) did not differ from unrelated targets (p=0.548) indicating that the RH activates only dominant meanings in short ISIs (See Figure 16).

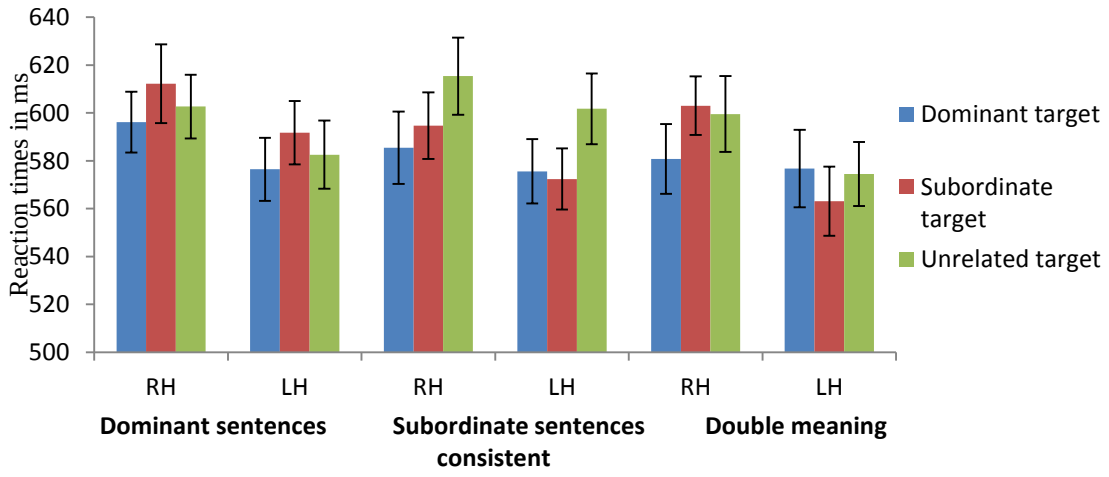

Figure 16 Mean RTs (ms) for the dominant, subordinate and the unrelated targets in the two hemispheres following homonyms in dominant-consistent, subordinate-consistent and double-meaning consistent contexts. Error bars indicate the standard error of the mean per condition.

ANOVA to examine effects for polysemous words

In the ANOVA computed for polysemous words only the main effect of Target type reached significance [*F1*(2,40) = 42.850, MS = 25299, *p*<0.0001, η_p^2 = 0.682; *F2*(2,58)=9.40, MS=42297, *p*<0.0003, η_p^2=0.245]. Furthermore, the two-way interaction of Context and Target type was also significant [*F1*(4,80) = 5.299, MS = 2390, *p*<0.0007, η_p^2 = 0.209; *F2*(4,116)=3.87, MS=3966, *p*<0.005, η_p^2=0.118], as well as the three-way interaction of Context, Target type and Visual Field (by subjects) [*F1*(4,80) = 2.523, MS = 1221, *p*<0.047, η_p^2 = 0.112; *F2*(4,116)=1.06, MS=1189, *p*=0.379, η_p^2=0.035].

Post-hoc tests to explore further the main effect of Target type revealed that only dominant targets (572ms) showed priming effects relative to unrelated targets (597ms; *p*<0.0001), while subordinate targets (597ms) did not differ from unrelated ones (*p*=0.839). Post-hoc comparisons to investigate further the significant interaction of Context and Target type revealed a pattern which indicates that only dominant meanings were activated in all three types of sentences. More specifically, after dominant consistent sentences, dominant targets (567ms) were significantly faster than unrelated targets (594ms, *p*<0.001), while subordinate targets (606ms) were not statistically different from unrelated ones (*p*=0.073). Similarly, after subordinate consistent sentences, dominant targets (579ms) were significantly faster than unrelated targets (596ms, *p*<0.004) while, again, subordinate targets (589ms) were not statistically different from unrelated ones (*p*=0.474). However, a closer look at the activation levels of subordinate targets reveals that they improved significantly when they appeared after subordinate consistent sentences compared to dominant consistent sentences (*p*<0.008), indicating that subordinate contexts can guide access to subordinate senses of polysemous words. Finally, after double-meaning consistent sentences, only dominant targets (571ms) were significantly faster than unrelated targets (600ms, *p*<0.0001) while subordinate targets (596ms) were not statistically different from unrelated ones (*p*=0.715).

Post-hoc comparisons to explore further the significant three-way interaction of Context, Target type and Visual Field revealed the following hemispheric asymmetries. After dominant consistent sentences, the LH activated only dominant meanings (566ms) whereas subordinate ones (591ms) did not differ from unrelated targets (589ms; *p*<0.024 and *p*=0.981 respectively). In the same context, the RH activated dominant meanings (568ms) relative to unrelated targets (599ms; *p*<0.001) while subordinate ones exhibited a pattern of interference: their

reaction times (621ms) were significantly slower than unrelated targets (p<0.015). After subordinate consistent sentences, the LH activated only dominant meanings (567ms) whereas subordinate ones (583ms) did not differ from unrelated targets (589ms; p<0.032 and p=0.831 respectively). In contrast, in the same contexts, the RH did not activate either the dominant (591ms) or subordinate meanings (596ms), which did not differ from each other (p=0.745), relative to unrelated targets (604ms; p=0.512 and p=0.791 respectively). After double-meaning consistent sentences, the LH activated only dominant meanings (559ms) whereas subordinate ones (586ms) did not differ from unrelated targets (597ms; p<0.0001 and p=0.622 respectively). In the same context, in the RH there was no facilitation for dominant (582ms) or subordinate targets (606ms) relative to unrelated ones (603ms; p=0.108 and p=0.839 respectively). However, dominant targets were processed significantly faster than subordinate targets (p<0.031) (See Figure 17). Thus, the pattern of meaning activation for the senses of polysemous words indicates that while the LH invariably activated dominant meanings in all three contexts, the RH was more sensitive to the subordinate meanings of polysemous words in dominant meaning consistent contexts. Mean reaction times for all conditions are presented in Table 17. Additionally, Table 18 shows all significant main and interaction effects from Experiment 7 in comparison to the main and interaction effects from Experiment 3, in which we used semantic priming with central presentation of targets.

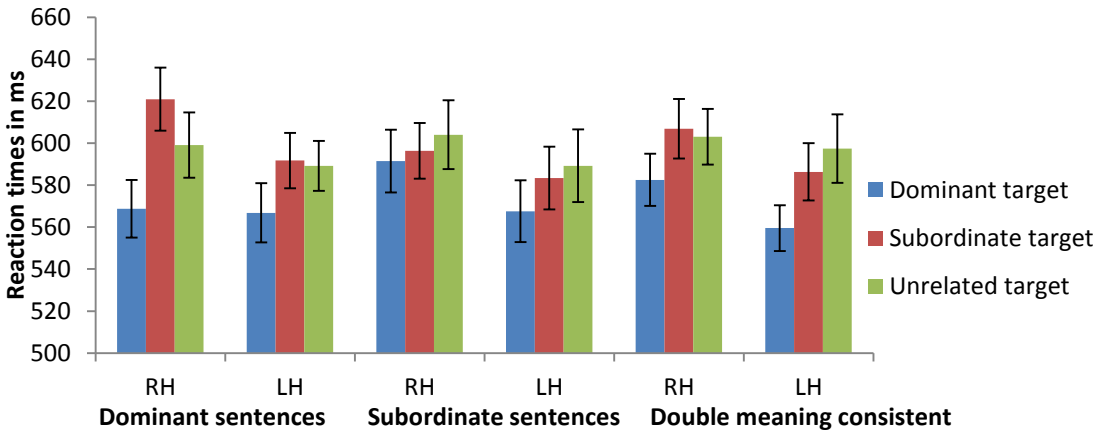

Figure 17 Mean RTs (ms) for the dominant, subordinate and the unrelated targets in the two hemispheres following polysemous words in dominant-consistent, subordinate-consistent and double-meaning consistent contexts. Error bars indicate the standard error of the mean per condition.

Table 17 Mean RTs (ms) for all conditions in Experiment 7. Standard deviations are indicated in parentheses.

Lexical Ambiguity	**Homonymy**						**Polysemy**					
Context	**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-Meaning consistent**		**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-meaning consistent**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Dominant Target	596 (58)	577 (61)	586 (69)	576 (62)	580 (67)	576 (74)	569 (63)	567 (65)	592 (69)	569 (67)	583 (57)	560 (50)
Subordinate Target	611 (75)	593 (61)	594 (64)	573 (58)	603 (56)	565 (66)	619 (69)	593 (61)	595 (61)	585 (68)	607 (65)	587 (62)
Unrelated Target	600 (61)	581 (65)	614 (74)	602 (68)	600 (73)	575 (61)	597 (71)	589 (55)	602 (75)	589 (79)	601 (61)	598 (75)

Table 18 Significant main and interaction effects from Experiment 3 (early processing of puns based on ambiguous words with central presentation for the targets) and Experiment 7 (early processing of puns based on ambiguous words with lateralised presentation for the targets).

	Main and interaction effects	**Degrees of freedom**	***F* value**	**MS**	***P***	η_p^2
Experiment 3	**Context**	2,38	3.606	1017	0.037	0.160
	Target type	2,38	24.538	11489	0.001	0.564
	Lexical Ambiguity X Context	2,38	8.668	1958	0.001	0.313
	Lexical Ambiguity X Target type	2,38	9.508	3324	0.0004	0.334
Experiment 7	**Target type**	2,40	46.393	26937	0.001	0.699
	Visual Field	1,20	5.085	58610	0.036	0.203
	Lexical Ambiguity X Context	2,40	4.590	1968	0.016	0.187
	Lexical Ambiguity X Target type	2,40	10.912	4710	0.0001	0.353
	Context X Target Type	4,80	6.375	4111	0.0001	0.242
	Lexical Ambiguity X Context X Target Type	4,80	3.166	1735	0.018	0.137
	Lexical Ambiguity X Context X Target type X Visual Field	4,80	2.560	1678	0.045	0.113

Accuracy rates:

Similar to the reaction time data, the Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) x Visual Field (left visual filed, right visual field) ANOVA carried out with accuracy (ACC) data revealed significant main effects of Lexical Ambiguity, [*F1*(1,20) = 7.580, MS = 27.049, *p*<0.012, η_p^2 = 0.275; *F2*(1,29) = 5.085, MS = 21.393, *p*<0.032, η_p^2 = 0.149], and Target type [*F1*(2,40) = 36.738, MS = 185.905, *p*<0.0001, η_p^2 = 0.648; *F2*(2,58) = 20.670, MS = 129.919, *p*<0.0001, η_p^2 = 0.416]. Additionally, the ANOVA revealed significant two-way interaction effects of Lexical Ambiguity and Target type (by subjects) [*F1*(2,40) = 11.197, MS = 27.577, *p*<0.0001, η_p^2 = 0.359; *F2*(2,58) = 2.537, MS = 17.545, *p*=0.089, η_p^2 = 0.080], and Context and Target Type, [*F1*(4,80) = 6.678, MS = 12.967, *p*<0.0001, η_p^2 = 0.250; *F2*(4,116) = 2.745, MS = 9.861, *p*<0.032, η_p^2 = 0.086]. The four-way interaction of Lexical Ambiguity, Context, Target type and Visual Field was also significant (by subjects) [*F1*(4,80) = 3.987, MS = 8.059, *p*<0.005, η_p^2 = 0.166; *F2*(4,116) = 1.164, MS = 4.968, *p*=0.330, η_p^2 = 0.038].

The significant main effect of Lexical Ambiguity revealed that participants made more errors for homonyms (2.74%) relative to polysemous words (2.36%; *p*<0.012). Moreover, post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the main effect of Target type revealed that errors made both to dominant targets (1.73%) and subordinate targets (2.49%) were significantly lower than unrelated targets (3.44%; *p*<0.0001 in both cases). The difference between the error rates for the two related targets also reached significant levels (*p*<0.0005) indicating that participants made more errors for subordinate targets.

Post-hoc comparisons to explore further the significant interaction of Lexical Ambiguity and Target type revealed different error rates for homonymous and polysemous words. On the one hand, for homonyms, error rates both for dominant (1.98%) and subordinate targets (2.32%) were significantly lower than unrelated targets (3.92%; *p*<0.0001 and *p*<0.0002 respectively) indicating that both meanings of the homonymous words were primed. However, for polysemous words, only error rates for dominant targets (1.47%) were significantly lower than unrelated ones (2.96%; *p*<0.0001), while subordinate targets did not differ from unrelated ones (2.66%; *p*=0.135).

Post-hoc comparisons to explore further the significant interaction effects of Context and Target type indicated that after dominant consistent sentences only error rates for dominant targets (1.43%) were significantly lower relative to unrelated ones (3.42%; p<0.0001). After subordinate consistent sentences, error rates for both dominant (2.07%) and subordinate targets (2.21%) were significantly lower than unrelated targets (3.44%; p<0.0001 in both cases), which is consistent with an exhaustive access model of meaning activation for ambiguous words. Following the double-meaning consistent sentences, error rates for both dominant (1.68%) and subordinate targets (2.21%) were significantly lower than unrelated targets (3.46%; p<0.0001 in both cases). Thus, the results suggest that dominant meanings are always activated, while the activation of subordinate meanings is more context sensitive as they are activated only in contexts that bias them explicitly, namely the subordinate consistent and double-meaning consistent contexts. The four-way interaction between all the independent variables also reached significant levels. Therefore, in order to explore in detail the underlying assumptions for homonyms and polysemous words two separate ANOVAs (3 x 3 x 2) were conducted for homonymy and polysemy with Context, Target type and Visual field as the independent variables.

ANOVA to examine effects for homonymous words

In the ANOVA computed for homonyms there was a significant main effect of Target type [$F1$(2,40) = 38.046, MS = 135.058, p<0.0001, η_p^2= 0.655; $F2$(2,58)=10.006, MS=94.541, p<0.0002, η_p^2=0.257]. The two-way interaction of Context and Target type also reached significant levels (by subjects), [$F1$(4,80) = 5.783, MS = 11.451, p<0.0004, η_p^2= 0.224; $F2$(4,116)=1.597, MS=8.016, p=0.179, η_p^2=0.052].

Post-hoc comparisons that explored further the main effect of Target type indicated that errors for both dominant (1.98%) and subordinate targets (2.32%) were significantly lower than unrelated targets (3.92%; p<0.0001 in both cases). Post-hoc comparisons to explore further the significant two-way interaction effect of Context and Target type revealed the following patterns for the three sentential contexts. After dominant consistent sentences, only dominant targets (1.74%) showed significantly fewer errors relative to unrelated targets (3.67%; p<0.0001) while subordinate targets (3.09%) did not differ from unrelated targets (p=0.067). After subordinate consistent sentences, error rates for both dominant (2.26%) and subordinate targets (1.90%) were reduced relative to unrelated targets (4.07%, p<0.0001 in both cases). Similarly, after double-meaning consistent sentences error rates for both

dominant (1.95%) and subordinate targets (1.95%) were significantly reduced relative to unrelated targets (4.02%; *p*<0.0001 in both cases).

ANOVA to examine effects for polysemous words

In the ANOVA computed for polysemous words there was asignificant main effectof Target type [*F1*(2,40) = 19.738, MS = 78.423, *p*<0.0001, η_p^2=0.497; *F2*(2,58)=14.099, MS=52.924, *p*<0.0001, η_p^2=0327]. Additionally, the two-way interaction of Context and Target type was also significant (by subjects), [*F1*(4,80) = 2.766, MS = 4.947, *p*<0.033, η_p^2= 0.121; *F2*(4,116) = 1.822, MS = 4.071, *p*=0.129, η_p^2=0.059], as well as the three-way interaction between Context, Target type and Visual Field (by subjects), [*F1*(4,80) = 3.697, MS = 7.193, *p*<0.008, η_p^2= 0.155; *F2*(4,116) = 1.145, MS = 3.997, *p*=0.339, η_p^2=0.038].

Post-hoc comparisons to explore further the main effect of Target type revealed that only error rates for the dominant targets (1.47%) were significantly lower than those for the unrelated targets (2.96%, *p*< 0.0001). Error rates for the subordinate targets (2.66%) were not statistically different from the unrelated ones (*p*=0.237). Post-hoc tests that further explored the significant interaction of Context and Target type revealed that in all types of sentential context only dominant targets showed priming effects. More specifically, in dominant consistent sentences, error rates for dominant targets (1.12%) were significantly lower than for unrelated targets (3.16%; *p*<0.0001), while errors for subordinate targets (2.98%) were not different from unrelated ones (*p*=0.516). Similarly, in subordinate consistent sentences, error rates for dominant targets (1.88%) were significantly reduced compared to unrelated targets (2.81%; *p*<0.012), while subordinate (2.52%) and unrelated targets did not differ (*p*=0.331). The same pattern was observed in double-meaning consistent sentences, with dominant targets (1.40%) having significantly lower error rates than unrelated targets (2.90%; *p*<0.0001), while errors for the subordinate targets (2.48%) were not different from unrelated ones (*p*=0.461).

Finally, post-hoc comparisons conducted to explore further the significant three-way interaction of Context, Target type and Visual Field revealed the following hemispheric differences for the three sentential contexts. In dominant consistent contexts, the LH activated only the dominant meanings (1.14%) relative to the unrelated targets (2.48%; *p*<0.05), while the error rates for the subordinate targets (3.43%) were not different from the unrelated ones (*p*=0.408). Similarly, the RH activated only the dominant targets (1.09%) relative to the

unrelated targets (3.86%; $p<0.0001$) whereas the errors for the subordinate targets (2.52%) were not different from the unrelated ones ($p=0.064$). In subordinate consistent sentences, neither dominant nor subordinate meanings showed reduced error rates compared to unrelated targets in either hemisphere. Lastly, in double-meaning consistent sentences, the LH activated only dominant meanings (1.19%) relative to unrelated targets (2.90%; $p<0.01$), while the error rates for the subordinate targets (2.52%) were not different from the unrelated ones ($p=0.949$). In the same contexts, when presented to the RH neither dominant targets (1.62%) nor subordinate ones (2.43%) showed reduced error rates relative to unrelated targets (2.90%; $p=0.123$ and $p=0.954$ respectively). The percentage of errors for all conditions is presented in Table 19.

Table 19 Percentage of errors for all conditions in Experiment 7.

Lexical Ambiguity	**Homonymy**						**Polysemy**					
Context	**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-meaning consistent**		**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-meaning consistent**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Dominant Target	1.76%	1.71%	2.34%	2.29%	2.14%	1.76%	1.1%	1.14%	1.76%	2%	1.62%	1.19%
Subordinate Target	3.52%	2.67%	1.95%	1.86%	1.71%	2.19%	2.52%	3.43%	2.86%	2.19%	2.43%	2.52%
Unrelated Target	3.57%	3.76%	4.52%	3.62%	3.86%	4.19%	3.86%	2.48%	2.81%	2.81%	2.9%	2.9%

5.2.3 Discussion

Overall, the results obtained from Experiment 7 show two important findings. Firstly, the data point to sense-relatedness effects for ambiguous words used in sentential context. In particular, while only dominant senses of polysemous words reached activation levels in all three contexts, the meanings of homonymous words exhibited a different pattern of activation. The data suggested that for homonymous words there were competition effects between the dominant and subordinate meanings in double-meaning consistent contexts, and

exhaustive access to both dominant and subordinate meanings in subordinate-meaning consistent contexts. Furthermore, the results were consistent with the previous study that employed ambiguous words in punning contexts (Experiment 3) by further attesting that polysemous punning contexts are harder to process relative to homonymous punning contexts. However, the data did not indicate differential hemispheric processing for poysemous and homonymous puns. It was expected that processing polysemous puns might engage bilateral networks, whereas processing homonymous puns would rely entirely on the processing resources of the LH. Consistent with Klepousniotou et al. (2012) there was some indication that the RH might be implicated in the processing of the subordinate senses of polysemous words, but it was only evident for the subordinate senses of polysemous words in non-punning contexts.

In order to investigate further the hemispheric differences in processing ambiguous words in contexts and to explore the possibility of differential hemispheric processing for polysemous and homonymous puns during the later stages of language processing, a second experiment was designed in which the target words were still displayed laterally but with a delay of 750ms. In Experiment 8 we expected to observe further evidence for sense-relatedness effects for ambiguous words used in contexts. Additionally, consistent with the hypothesis of a slower rise time for subordinate senses/meanings in the RH (Koivisto, 1998), it was reasoned that any hemispheric differences between polysemous and homonymous puns might be more clearly observed during this later stage of pun processing when all possible meanings would be expected to have been activated.

5.3 Experiment 8

5.3.1 Method

Participants:

Twenty four native speakers of English (11 male and 13 female) with an average age of 22 years (range 18-35) and an average of 14.6 years of education (range 13-21) took part in the experiment for remuneration. All participants were right-handed, as assessed according to the Handedness Inventory by Briggs and Nebes, 1975, with normal or corrected to normal vision and no history of either neurological or language impairments. The experiment received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #12-0092; Appendix 1(a)).

Design, Materials and Procedure:

This experiment used the same materials and design as Experiment 7. The procedure was also the same apart from a modulation of the inter-stimulus interval. In order to explore hemispheric differences in pun processing during a later stage of processing, the lateralised target was presented with a delay of 750ms (ISI: 750ms).

5.3.2 Results

Non-experimental stimuli (all filler sentences followed by non-words) were removed from the analysis. The data from one participant was excluded from the data set as they failed to follow the instructions of the experiment. Prior to statistical analyses, errors (7.9%) and outliers (4.6%) (±2 standard deviations from each participant's mean per condition) were removed. Data were then subjected to a 2(Lexical Ambiguity: homonymy, polysemy) x 3(Context: dominant consistent, subordinate consistent, double-meaning consistent) x 3(Target type: dominant related, subordinate related and unrelated) x 2(Visual Field: left visual field, right visual field) repeated measures ANOVA for subjects (F1) and items (F2). The process was repeated for both reaction time (RT) and accuracy (ACC) data. All significant main and interaction effects were explored further using the Newman-Keuls (p<.05) post-hoc tests.

Response Latencies

The Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) x Visual Field (left visual field, right visual field) ANOVA carried out with reaction time (RT) data revealed significant main effects of Target type, [*F1*(2,44) = 35.296, MS = 31534, *p*<0.0001, η_p^2 = 0.616; *F2*(2,58) = 8.16, MS = 49773, *p*<0.0007, η_p^2 = 0.219] and Visual Field, [*F1*(1,22) = 18.320, MS = 98441, *p*<0.0003, η_p^2 = 0.454; *F2*(1,29) = 92.04, MS = 131531, *p*<0.0001, η_p^2 =0.760]. Additionally, there were significant two-way interactions of Context and Target type, [*F1*(4,88) = 8.156, MS = 3764, *p*<0.0001, η_p^2 = 0.270; *F2*(4,116) = 6.44, MS = 6154, *p*<0.0001, η_p^2 = 0.182], Context and Visual Field (by subjects), [*F1*(2,44) = 3.400, MS = 1448, *p*<0.042, η_p^2 = 0.133; *F2*(2,58) = 1.94, MS = 1606, *p*=0.153, η_p^2 = 0.063], as well as Target type and Visual Field, [*F1*(2,44) = 11.865, MS = 6854, *p*<0.0001, = 0.350; *F2*(2,58) = 7.85, MS = 8010, *p*<0.0009, η_p^2 = 0.213].

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant main effect of Target type revealed that reaction times both to dominant (603ms) and subordinate targets (614ms) were significantly faster than unrelated targets (625ms; $p<0.0001$ and $p<0.0003$ respectively). Consistent with a re-ordered access model, dominant targets were also faster than subordinate targets ($p<0.0002$). The post-hoc comparisons to explore the differences between the two visual fields indicated that responses made for targets in the right visual field-LH (603ms) were significantly faster than those for targets presented in the left visual field-RH (625ms; $p<0.0004$) indicating the overall LH advantage observed in language experiments.

Post-hoc comparisons to explore further the significant interaction effect of Context and Target Type revealed the following patterns for the three sentential contexts. After dominant consistent sentences, only dominant targets (600ms) showed robust priming effects relative to unrelated targets (629ms; $p<0.0001$). There was a strong tendency for subordinate targets (622ms) to be faster than unrelated ones but the difference was only marginally significant ($p<0.058$). Following subordinate consistent sentences, both dominant (609ms) and subordinate targets (608ms) showed robust priming effects relative to unrelated targets (619ms; $p<0.006$ and $p<0.004$ respectively) indicating that subordinate contexts successfully guided access to the subordinate meanings. Similarly, after double-meaning consistent sentences, both dominant (601ms) and subordinate targets (613ms) also showed facilitation relative to unrelated targets (626ms; $p<0.0001$ and $p<0.001$ respectively) pointing to the assumption that at the long ISI both related meanings were retrieved and facilitated in pun contexts (unlike the results at the short ISI which showed that after double-consistent sentences only dominant meanings reached activation).

Post-hoc comparisons to explore further the significant interaction of Context and Visual Field revealed the following pattern. In the LH, there were no significant differences between dominant consistent (603ms), subordinate consistent (603ms) and double-meaning consistent sentences (604ms). In contrast, in the RH, dominant consistent sentences (630ms) were processed significantly slower relative to subordinate consistent (622ms) and double meaning consistent sentences (623ms; $p<0.003$ and $p<0.005$ respectively), pointing to the role the RH plays in activating more distantly related meanings that were required for these two contexts (see Figure 18).

Lastly, post-hoc comparisons to explore further the significant interaction effects of Target type and Visual Field indicated the following patterns. In the LH, both dominant (597ms) and

subordinate meanings (598ms) showed strong priming effects in comparison to unrelated targets (615ms; $p<0.0001$ in both cases), while dominant and subordinate targets did not differ from each other ($p=0.62$). In the RH, only dominant targets (610ms) showed facilitation relative to unrelated ones (634ms; $p<0.0001$). Subordinate targets (631ms) were not statistically different from unrelated ones ($p=0.259$). Thus, the results indicate that the LH activates exhaustively both dominant and subordinate meanings, while the RH only has access to the dominant meanings (see Figure19). Additionally, Table 20 shows all significant main and interaction effects from Experiment 8 in comparison to the main and interaction effects from Experiment 4, in which we used semantic priming with central presentation of targets. Mean reaction times for all conditions are presented in Table 21.

Table 20 Significant main and interaction effects from Experiment 4 (late processing of puns based on ambiguous words with central presentation for the targets) and Experiment 8 (late processing of puns based on ambiguous words with lateralised presentation for the targets).

	Main and interaction effects	**Degrees of freedom**	***F* value**	**MS**	***P***	η_p^2
Experiment 4	**Target type**	2,36	20.5207	10517	0.001	0.533
	Lexical Ambiguity X Target type	2,36	5.153	2361	0.011	0.223
	Context X Target type	4,72	2.434	810	0.05	0.119
Experiment 8	**Target type**	2,44	35.296	31534	0.0001	0.616
	Visual Field	1,22	18.320	98441	0.0003	0.454
	Context X Target type	4,88	8.156	3764	0.0001	0.270
	Context X Visual Field	2,44	3.400	1448	0.042	0.133
	Target type X Visual Field	2,44	11.865	6854	0.0001	0.350

Table 21 Mean RTs (ms) for all conditions in Experiment 8. Standard deviations are indicated in parentheses.

Lexical Ambiguity	**Homonymy**						**Polysemy**					
Context	**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-Meaning consistent**		**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-Meaning consistent**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Dominant Target	616 (56)	590 (60)	622 (63)	602 (51)	602 (63)	601 (52)	600 (58)	590 (61)	613 (57)	601 (62)	604 (64)	569 (58)
Subordinate Target	639 (61)	600 (54)	615 (75)	594 (59)	629 (65)	591 (62)	639 (63)	608 (55)	630 (57)	592 (51)	629 (61)	603 (63)
Unrelated Target	640 (65)	614 (69)	617 (58)	612 (61)	637 (69)	618 (70)	644 (61)	616 (60)	631 (58)	613 (68)	634 (65)	613 (74)

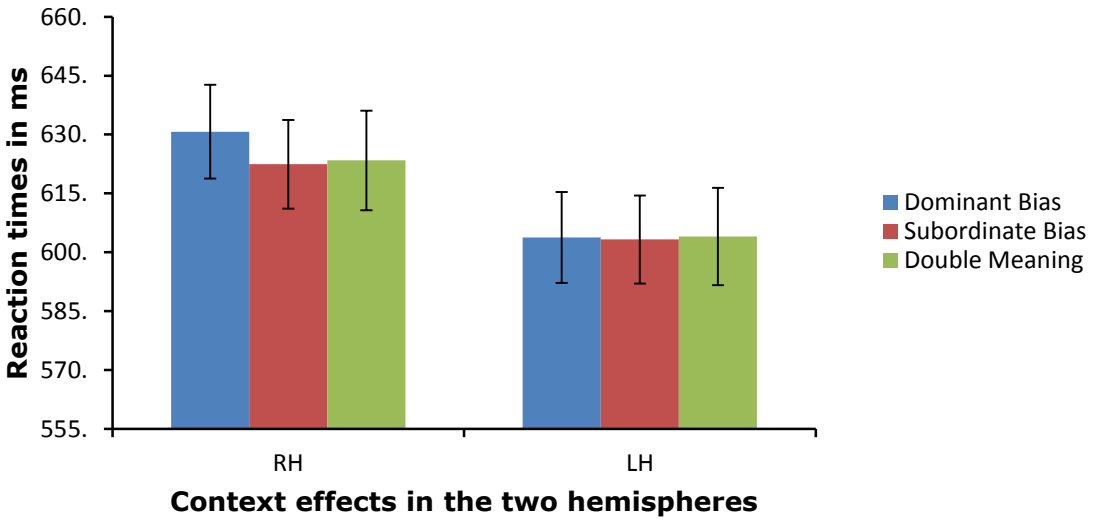

Figure 18 Mean RTs (ms) for the three types of sentence contexts, dominant bias, subordinate bias and double-meaning, in the two hemispheres. Error bars indicate the standard error of the mean per condition.

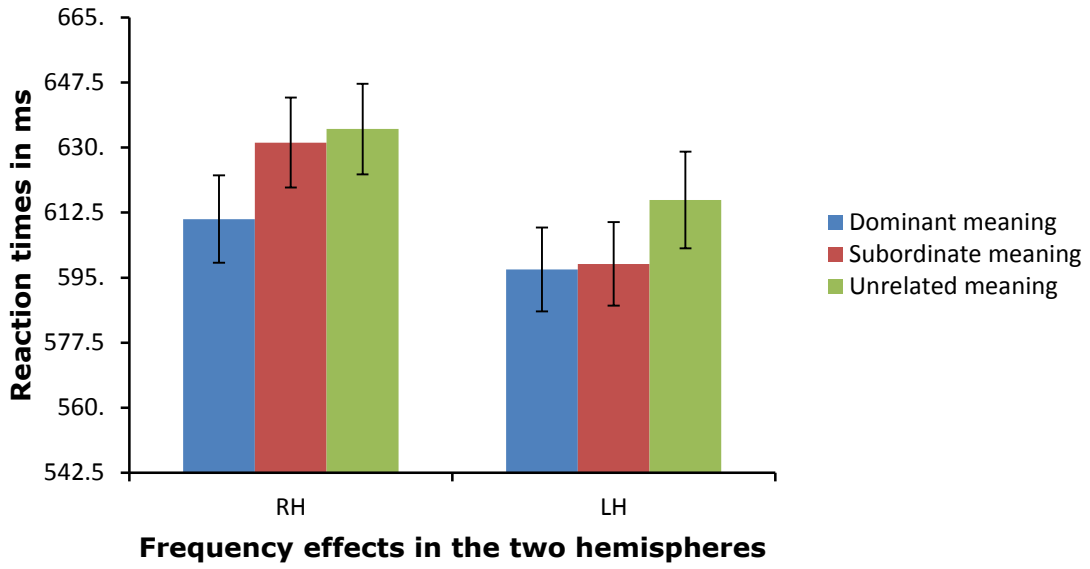

Figure 19 Mean RTs (ms) for the dominant, subordinate and the unrelated meanings in the two hemispheres. Error bars indicate the standard error of the mean per condition.

Accuracy rates:

Similar to the reaction times data, the Lexical Ambiguity (homonymy, polysemy) x Context (dominant-consistent, subordinate-consistent, double-meaning consistent) x Target type (dominant-related, subordinate-related and unrelated) x Visual Field (left visual filed, right visual field) ANOVA carried out with accuracy (ACC) data revealed significant main effects of Lexical Ambiguity (by subjects), [*F1*(1,22) = 7.197, MS = 16.816, *p*<0.014, η_p^2=0.246; *F2*(1,29) = 2.729, MS = 12.893, *p*=0.109, η_p^2= 0.086] and Target type, [*F1*(2,44) = 33.540, MS = 126.465, *p*<0.0001, η_p^2= 0.604; *F2*(2,58) = 19.943, MS = 96.956, *p*<0.0001, η_p^2= 0.407]. Furthermore, the two-way interaction of Lexical Ambiguity and Target type also reached significant levels (by subjects), [*F1*(2,44) = 6.111, MS = 15.791, *p*<0.004, η_p^2= 0.217; *F2*(2,58) = 2.218, MS = 12.106, *p*=0.118, η_p^2= 0.071]. Lastly, the three-way interaction of Lexical Ambiguity, Context and Target type was also found to be significant (by subjects), [*F1*(4,88) = 2.542, MS = 4.188, *p*<0.045, η_p^2= 0.104; *F2*(4,116) = 1.363, MS = 3.211, *p*=0.251, η_p^2= 0.045].

Post-hoc comparisons with the Newman-Keuls test (p<.05) to explore further the significant main effect of Lexical Ambiguity revealed that error rates for homonymous words (2.53%) were significantly higher relative to polysemous words (2.24%; *p*<0.014). Post-hoc tests to explore further the main effect of Target type indicated that error rates for both dominant (1.83%) and subordinate targets (2.18%) were significantly lower relative to unrelated ones

(3.14%; p<0.0001 in both cases). Furthermore, the difference in errors between the two types of related targets was also significant (p<0.039). Post-hoc comparisons to explore further the significant interaction of Lexical Ambiguity and Target Type did not indicate any interesting differential processing for homonymy and polysemy. More precisely, error rates both for the dominant and subordinate targets for both homonyms and polysemous words were significantly lower relative to the baseline unrelated targets. There were no differences either based on meaning frequency or sense/meaning relatedness.

Lastly, post-hoc comparisons with the Newman-Keuls test (<.05) to investigate further the three-way interaction of Lexical Ambiguity, Context and Target type revealed the following patterns. For homonyms, after dominant consistent sentences, error rates both for the dominant targets (1.67%) and the subordinate targets (2.41%) were significantly lower relative to the unrelated targets (3.22%; p<0.001 and p<0.029 respectively). After subordinate consistent sentences, again error rates both for the dominant (2.35%) and the subordinate targets (1.85%) were lower relative to the unrelated targets (3.80%; p<0.0001 in both cases). Similarly, after double-meaning consistent sentences, the error rates for both dominant (1.76%) and subordinate targets (2.09%) were significantly lower than unrelated targets (3.61%; p<0.0001 in both cases). On the other hand, for polysemous words, after dominant consistent sentences only error rates for dominant targets (1.61%) were significantly lower than unrelated targets (2.71%; p<0.005) while subordinate targets (2.37%) and unrelated targets did not differ (p=0.566). After subordinate consistent sentences, it was again only the error rates for the dominant targets (1.67%) that were significantly lower than the unrelated ones (2.76%; p<0.007) while subordinate targets (2.39%) and unrelated targets did not differ (p=0.6). However, after the double-meaning consistent sentences, the error rates for neither the dominant (1.93%) nor the subordinate targets (2.00%) were significantly lower than the unrelated targets (2.74%; p=0.079 and p=0.118 respectively; although there was a slight trend for dominant targets to show priming effects) indicating possibly that the two senses of polysemous words may actually be antagonistic to each other when it comes to a context that intentionally attempts to juxtapose them. The percentage of errors for all conditions is presented in Table 22.

Table 22 Percentage of errors for all conditions in Experiment 8.

Lexical Ambiguity	**Homonymy**						**Polysemy**					
Context	**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-Meaning consistent**		**Dominant Meaning consistent**		**Subordinate Meaning consistent**		**Double-Meaning consistent**	
Visual Field	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**	**LVF**	**RVF**
Dominant Target	1.74%	1.61%	2.48%	2.22%	1.91%	1.61%	1.43%	1.78%	1.83%	1.52%	2.09%	1.78%
Subordinate Target	2.78%	2.04%	1.65%	2.04%	2.09%	2.09%	2.57%	2.17%	2.61%	2.17%	1.91%	2.09%
Unrelated Target	3.65%	2.78%	3.87%	3.74%	3.78%	3.43%	2.96%	2.48%	2.74%	2.78%	2.91%	2.57%

5.3.3 Discussion

Overall, the results from Experiment 8 suggest two important findings. Firstly, even though there is some evidence from the accuracy data that sense-relatedness produced differential patterns of meaning activation for polysemous and homonymous words, the effects are highly attenuated as they were not observed in the response latency data (unlike the results from Experiment 7 that clearly suggested sense-relatedness effects for ambiguous words in context). As a corollary, there was no indication for the distinction between polysemous puns and homonymous puns. Secondly, as a consequence of the lack of sense-relatedness effects in punning contexts, the working hypothesis that polysemous puns might require bilateral processing while homonymous puns require LH processing was not confirmed. However, the results suggest the RH's preferential involvement during the processing of double-meaning consistent contexts. Unlike the results obtained from Experiment 7, RH effects were observed irrespective of sense-relatedness effects, indicating that the RH was involved in the processing of puns motivated by ambiguous words in general.

5.4 General Discussion

The present study aimed to further our knowledge of sense-relatedness effects for ambiguous words used in context as well as to explore hemispheric asymmetries for processing double-meaning consistent contexts (i.e., puns) motivated by polysemous and homonymous ambiguous words (i.e., polysemous and homonymous puns). It was comprised of two hemi-field semantic priming experiments that explored the time-course of meaning activation in the two hemispheres. Experiment 7 employed a short ISI (0ms) to tap onto the early stages of meaning access, while Experiment 8 employed a long ISI (750ms) to target a later stage of attention-driven processing. Consistent with the results of the behavioural study with central presentation discussed in Chapter 3, the current data indicated sense-relatedness effects in dominant-meaning and subordinate-meaning consistent contexts suggesting that polysemous and homonymous ambiguous words in context were processed differently. The pattern of results has implications for the mental representations of the two types of ambiguous words. Additionally, the present study also pointed to sense-relatedness effects in double-meaning consistent contexts suggesting that polysemous and homonymous puns were also processed differently. Furthermore, consistent with the results in Chapter 3, the data from the current study indicated that polysemous puns were harder to process relative to homonymous puns. However, sense-relatedness effects for ambiguous words used in context were evident only in Experiment 7 suggesting that such effects might be a function of automaticity of language processing. The results from the current study were only partially consistent with the working hypothesis that polysemous puns would recruit bilateral processing networks, whereas homonymous puns would be processed exclusively in the LH. Even though the present data again pointed to processing similarities between polysemous words and decomposable idioms on the one hand, and homonymous words and non-decomposable idioms on the other, hemispheric differences were not observed for polysemous and homonymous puns especially in the later stage of pun processing. Experiment 7 (ISI: 0ms) indicated that the RH was partially involved only for the processing of polysemous words in dominant-meaning consistent contexts but not punning contexts. Furthermore, there was no evidence for hemispheric differences for homonymous words in any of the three sentence contexts. Most importantly, however, the results from Experiment 8 (ISI: 750ms) suggest a RH advantage for the processing of double-meaning consistent sentences (irrespective of sense-relatedness). This result may not be consistent with previous experimental evidence which suggests that puns are processed exclusively in the LH (Coulson and Severens, 2007; Goel and Dolan, 2001; Kana and Wadsworth, 2012), but it is consistent with the RH hypothesis for non-literal language

processing (Giora, 2007) and the cognitive continuum hypothesis for non-literal language processing (Faust and Kenett, 2014) which argue that RH processing for non-literal language is dependent on the underlying linguistic nature of the particular non-literal linguistic structure. It is also consistent with our hypothesis that the internal semantics of puns is an important predictor for hemispheric asymmetries during pun comprehension.

Sense-relatedness and context effects

Consistent with the behavioural data with central presentation discussed in Chapter 3, the current study provides further evidence that when ambiguous words are employed in sentence contexts they exhibit different processing patterns as a function of sense-relatedness. These processing differences were observed predominantly in Experiment 7, which tapped automatic language processing, indicating that sense-relatedness effects are mostly evident during automatic spreading activation processes. In particular, as far as homonyms are concerned, consistent with the re-ordered access model (Duffy et al., 1988; Hogaboam and Perfetti, 1975), the data suggest that the multiple meanings were accessed exhaustively but in the order of their dominance. Furthermore, contextual bias effectively constrained the activation only of dominant meanings in dominant biasing contexts, while in subordinate biasing contexts parallel activation of both subordinate and dominant meanings was observed. Therefore, the subordinate context can indeed guide access to the subordinate meanings, while dominant meanings were also activated by default as a function of their dominance. Interestingly, the double-meaning consistent context (i.e., puns) appeared to have failed to facilitate either the dominant or the subordinate meaning of the sentence-final homonyms relative to the unrelated targets indicating competition effects between the two equally intended meanings. Recall that in Chapter 4 (Experiments 5 and 6) we observed the same competition effects for the literal and idiomatic meanings of non-decomposable puns pointing to the processing similarities of homonymous puns and non-decomposable puns.

As far as the activation patterns of polysemous words are concerned, the data suggest that there was consistent preference for dominant senses. However, even though statistically it was only the dominant senses that reached significant activation levels relative to the unrelated baseline in all contexts, a closer look at the data reveals finer and more intricate context effects for polysemous words and their multiple senses. In particular, following dominant-consistent sentences, dominant senses showed strong priming effects while subordinate senses showed interference effects, i.e., their activation levels were significantly lower than the unrelated baseline. In subordinate-consistent sentences, however, subordinate

senses received significantly more priming than when they were presented after dominant-consistent sentences, even though, again, only the dominant senses remained strongly activated relative to baseline. In double-meaning consistent sentences, the dominant senses received more priming than after subordinate consistent contexts but less priming than after dominant consistent contexts; the subordinate senses, on the other hand, received more priming than after dominant consistent sentences, but less than after subordinate consistent context. Thus, it becomes clear that double-meaning consistent contexts have a differential effect on the activation pattern of the two senses of sentence-final polysemous words. In particular, double-meaning consistent contexts boost the activation of the dominant senses relative to the subordinate consistent context, but not relative to the dominant consistent context. Simultaneously, they also boost the activation of the subordinate senses relative to the dominant meaning consistent context but not relative to the subordinate consistent context. Overall, the double-meaning consistent contexts failed to indicate competition effects between the dominant and subordinate senses of polysemous words. Recall from the previous chapter (Chapter 4, Experiments 5 and 6) that we also failed to observe competition effects between the literal and idiomatic meanings of decomposable idioms in double-meaning consistent punning contexts pointing to processing similarities between polysemous and decomposable puns. Thus, the results from the present study seem to point to the conclusion that sense-relatedness effects were observable both in biasing single-meaning consistent contexts (but cf. Klepousniotou et al., 2005b) as well as in punning double-meaning consistent contexts.

A more direct comparison between the punning contexts motivated by the unrelated meanings of homonymous words and the punning contexts motivated by the related senses of polysemous words reveals competition effects between the dominant and subordinate meanings of homonymous words, and facilitative effects between the dominant and subordinate senses of polysemous words. Such patterns of results are analogous to the competition effects for the literal and idiomatic meanings of non-decomposable idioms in double-meaning consistent contexts and the facilitative effects in the same contexts for the literal and idiomatic meanings of decomposable idioms. To be more specific, the previous chapter discussed the idea that the unrelated literal and idiomatic meanings of non-decomposable idioms become equally 'response relevant' in a punning context that causes them to compete with each other and results in both of them failing to achieve activation. Conversely, the two related literal and idiomatic meanings of decomposable idioms did not become equally 'response relevant' in a punning context as this context seemed to focus

predominantly on the literal meanings making them seem as if they were the only response-relevant option. To relate back to the current study, in a similar manner to the non-decomposable puns, the unrelated dominant and subordinate meanings of homonymous words become equally response-relevant in the punning context that caused them to compete with each other preventing activation for either of the two meanings. Furthermore, similar to decomposable puns, the related dominant and subordinate senses of polysemous words were probably not perceived as equally response-relevant as the punning context placed extra focus on the dominant senses making them appear as the more response-relevant option and thus resolving the interference effects that were observed for the subordinate senses in dominant-meaning consistent contexts.

The sense-relatedness effects observed in biasing single-meaning consistent contexts and punning double-meaning consistent contexts have implications for models of meaning representation in mental space. In particular, the data presented here support the differential mental representations for homonymous and polysemous words. In particular, both the exhaustive access to the unrelated meanings of homonymous words in the two biasing contexts, and the competition effects in the punning contexts suggest that the two unrelated meanings of homonymous ambiguous words most likely have different mental representations in mental space. On the other hand, the consistent strong preference for the dominant senses of polysemous words in all contexts, together with the facilitative effects for the subordinate meanings in double-meaning consistent contexts suggest that both dominant and subordinate senses of polysemous words most likely share the same mental representation. Furthermore, the finding that the subordinate senses of polysemous words showed differential priming effects as a function of contextual bias but never managed to reach strong activation levels points to the assumption that ambiguous words which have senses that rely on a high degree of semantic overlap might realise their subordinate sense via a core meaning representation (i.e., the dominant sense) (see Klepousniotou et al., 2008).

Hemispheric contributions in processing polysemous and homonymous puns

A second key point of interest in the present study was to investigate the possibility that polysemous puns might recruit the processing networks of the two hemispheres, while homonymous puns might exhibit a clearer LH preference. It was hypothesized that if processing polysemous puns is similar to processing decomposable puns, then polysemous puns might be processed bilaterally as has been shown for decomposable puns that require the two hemispheres to an equal extent to provide additional processing resources.

Conversely, if processing homonymous puns is similar to processing non-decomposable puns, then homonymous puns might be processed exclusively in the LH as has been shown for non-decomposable puns (see Chapter 4). However, instead of indicating bilateral processing for polysemous puns and a LH advantage for homonymous puns, the results indicate an overall RH advantage for processing puns based on ambiguous words irrespective of sense-relatedness effects. It is argued here that in addition to sense-relatedness effects and decomposition effects, pun processing in the two hemispheres might be affected by the degree of plausibility of each of a pun's two intended meanings. In particular, if the two intended meanings in a pun are both equally plausible utterances, the language processor might require additional processing resources from the RH (see Connell, 2004 for the effects of plausibility on processing costs).

The present data only partially confirm the prediction of a possible processing similarity between decomposable puns and polysemous puns on the one hand, and non-decomposable puns and homonymous puns on the other. The processing similarities between polysemous puns and decomposable puns, and homonymous puns and non-decomposable puns are further strengthened by the processing similarities between polysemous words and decomposable idioms, and homonymous words and non-decomposable idioms. In particular, even though processing the subordinate senses of polysemous words in non-punning contexts did exhibit a pattern comparable to the processing of the idiomatic meanings of decomposable idioms in non-punning contexts (i.e., in both cases interference effects were detected in the RH), the data did not indicate that *polysemous puns* were processed bilaterally. It is likely that in both cases this interference effect in non-punning contexts was driven (i) by the very close semantic similarity between dominant and subordinate senses of polysemous words, and literal and idiomatic meanings of decomposable idioms and (ii) by the lack of an autonomous semantic representation both for the subordinate senses of polysemous words and the idiomatic meanings of decomposable idioms. Furthermore, when polysemous words and decomposable idioms were used in punning contexts, the interference effects disappeared thus suggesting a similar effect for the punning contexts. Additionally, processing the unrelated meanings of homonymous words did exhibit a pattern comparable to processing of the unrelated literal and idiomatic meanings of non-decomposable idioms. For example, in non-punning contexts, both literal and idiomatic meanings were activated and both dominant and subordinate meanings were also activated; in punning contexts, neither literal nor idiomatic meanings were activated and neither dominant nor subordinate meanings were activated either. However, again, despite the similarities, the LH advantage for the processing

of *non-decomposable puns* did not translate to a LH advantage for the processing of *homonymous puns*.

Therefore, while it is obvious that the close semantic similarities between the different meanings/senses of the linguistic expression motivating the punning context are an important variable that can predict some aspects of pun processing (e.g., processing costs) it also becomes clear that perhaps hemispheric differences are affected by an additional factor as well. A closer look at non-decomposable and decomposable puns, and polysemous and homonymous puns reveals that the semantic nature of these puns also differs along the lines of what is existentially possible in our world. For example, for many of the non-decomposable puns one of the intended meanings that forms part of the pun does not constitute a possible utterance in its own right. In the pun '*The chef has to make sure he does not* ***cook the books****.'* the literal interpretation of a chef actually cooking books does not make sense (i.e., it is an implausible utterance). A similar situation occurs with many of the non-decomposable idioms; for example, to *shoot the breeze, to paint the town red, to bite the dust, to get someone in a stew* to mention just a few for which the literal interpretation is implausible. For the decomposable puns, however, the number of implausible literal interpretations is not so high as, by default, the idiomatic meanings of decomposable idioms are based on the literal interpretations. For example, in the pun '*I was a sprinter but I was* ***on the wrong track.'*** the literal interpretation of a sprinter being on the wrong track is a plausible and valid utterance. The issue of implausibility does not concern ambiguous words in the same way, if at all. When the two intended meanings of both polysemous and homonymous puns are considered, it becomes clear that both meanings constitute plausible and valid utterances. For example, in the homonymous pun '*I was a baker but I didn't make enough* ***dough.'*** each of the two intended meanings is a plausible utterance – it is conceivable to think of a baker who did not make enough mixture for a bread and at the same time think of a baker who did not make enough money. Also, in the polysemous pun '*I was an athlete but there were too many* ***hurdles.'*** each of the two intended meanings forms a valid and plausible utterance – (i) there were too many horizontal bars to jump and (ii) there were too many difficulties to jump. Thus, to conclude, it is conceivable that puns based on ambiguous words (irrespective of sense-relatedness effects) are different from puns based on idiomatic expressions in that puns based on ambiguous words are more likely to combine two plausible utterances in one syntactic form. In other words, each of the two intended meanings of a pun based on an ambiguous word is more or less equally plausible. Conversely, puns based on idiomatic expressions differ from puns based on ambiguous words because one of their expressions is likely to be an

implausible utterance, and non-decomposable puns are more likely than decomposable puns to have one utterance that is implausible.

Plausibility, and its importance for processing costs, has been investigated by Connell (2004). In that investigation, the researcher focused on three types of expressions that differed in plausibility; one group comprised of highly implausible expressions, the second group comprised of expressions that were of moderate plausibility and the third group comprised of expressions that were considered plausible. Connell (2004) found a positive correlation between plausibility and cognitive effort. In other words, the more plausible an expression was, the more cognitive effort was spent during its processing; also, the more implausible an expression was, the less cognitive effort was spent for processing. Connell suggested that there is a 'cognitive laziness' at play because the results implied that people do not put any effort into processing expressions that were outright implausible. This line of research has clear implications for the current study. To relate back to the case of puns, we can assume that people make the least effort to process non-decomposable puns as one of their interpretations is most likely to be an implausible interpretation. Decomposable puns require more processing effort (relative to non-decomposable puns) as there is greater likelihood for both of the pun's interpretations to be plausible ones. Finally, puns based on ambiguous words (irrespective of sense-relatedness effects) are most taxing to process as both meanings intended in the pun are valid and plausible utterances. To conclude, it is argued that in addition to the semantic similarities between the two meanings that give rise to a pun, the degree of plausibility of each intended utterance of a pun is another factor that might have affected pun processing in the current study. It could further be assumed that processing two intended meanings that are equally plausible, as in the case of puns motivated by the two meanings/senses of ambiguous words, might incur additional processing demands relative to puns that have only one plausible interpretation, necessitating thus additional resources and the recruitment of the RH.

Pun processing and the RH

Even though the finding that the RH is preferentially involved during non-literal language processing is not new (e.g., Faust and Mashal, 2007), the existing literature on pun processing has consistently failed to provide support for the RH hypothesis. To our knowledge, the current study is the only one to date to implicate the RH during the processing of puns. More specifically, in Experiment 8 (ISI: 750ms), irrespective of sense-relatedness effects, an overall preference of the RH was observed for the processing of the subordinate and double-meaning

consistent contexts (relative to the dominant meaning contexts). It is argued here that this preference is not simply a function of meaning dominance that would be consistent with research suggesting that subordinate and less frequent meanings have a slower rise in the RH (e.g., Simpson and Burgess, 1988). Instead it is argued that the RH's preference for subordinate and double-meaning contexts during the later stage of processing is mainly driven by contextual bias. To be more specific, if the RH involvement was due to meaning frequency only, we would expect the significant interaction of visual field and target type in Experiment 8 to indicate that the RH activates subordinate senses/meanings. Contrary to this expectation, the interaction revealed that the RH activated only the dominant meanings, while it was the LH that maintained activation for both dominant and subordinate meanings. Therefore, rather than simply being sensitive to lexical features such as meaning frequency, the results suggest that the RH is actually more sensitive to the contextual information held in subordinate consistent, and, more importantly, double-meaning consistent sentences.

The involvement of the RH during pun processing is consistent with the hypothesis that the RH is invoked in cases when higher processing demands have been incurred (Vigneau et al., 2011) and the 'summation priming' hypothesis (Beeman et al., 1994). In a meta-analysis to evaluate the role of LH and RH involvement in language processing, Vigneau et al. (2011) concluded that the RH is most consistently used during the processing of sentences or texts, namely when pragmatic interpretations are at play. Furthermore, they conclude that the RH appears to be recruited in situations with an increased demand for processing resources (e.g., cases that require selective attention and further manipulation of language in working memory). Similarly, the 'summation priming' paradigm argues that if three distantly related prime words such as CRY-FOOT-GLASS precede a target word such as CUT, which is loosely related to information provided by the combination of the three primes, that target will be processed better in the RH (Beeman et al., 1994). In addition, the results from the 'summation priming' paradigm indicate that the RH advantage is observed during later processing stages (Beeman et al., 1994). The processing of puns ultimately capitalises on the activation and integration of diffuse and weakly related concepts that fit into a single syntactic framework. It could be argued that the double meaning consistent context has a similar effect on the recognition of target words as the summative priming context. For example, a double-meaning consistent sentence such as '*The prince with a bad tooth got a* ***crown.'*** was followed by targets such as THRONE and DENTIST. Thus, each of the target words could equally benefit from the words *prince-tooth-crown* from the preceding prime (for a similar explanation regarding RH involvement during joke comprehension, see Coulson and Wu, 2005). We argue that the

differential involvement of the RH during pun processing in the present study is the outcome of the joint predictions derived from the processing demands hypothesis suggested by Vigneau et al (2011) and the 'summation priming' paradigm (Beeman et al., 1994). In particular, if the outcome of the summation process results in two intended and equally plausible interpretations in puns (e.g., one interpretation to center around THRONE and a second one to center around DENTIST), then we can assume that to hold and process the two equally plausible interpretations simultaneously will be harder relative to processing only one such interpretation. Hence, the RH is recruited for additional processing support. Thus, it seems that processing puns whose two interpretations are valid and plausible utterances might require additional processing resources relative to language that only conveys one intended plausible meaning. Such processing, then, necessitates additional resources from the RH.

Although it is very difficult to compare and draw conclusions from experiments that rely on so vastly different methodologies as those used so far with pun processing (e.g., Coulson and Severens, 2007; Goel and Dolan, 2001; Kana and Wadsworth, 2012), it is at least conceivable that any pun effect that could recruit the RH was largely obscured as none of the previous studies on pun processing investigated the importance of the underlying semantic nature of puns. It has become clear so far that puns motivated by different linguistic items are processed differently. For example, puns motivated by ambiguous words are processed differently from puns motivated by idiomatic expressions. What is even more striking is that the particular nature of ambiguous words and idiomatic expressions can result in further processing differences. For example, puns motivated by polysemous words are processed differently from puns motivated by homonymous words; similarly, puns triggered by decomposable idioms are processed differently from puns triggered by non-decomposable idioms. Thus, finer hemispheric differences could easily be obscured if the underlying nature of the punning expressions has not been taken into clear consideration. Such line of reasoning is consistent with Faust and Kenett (2014) who argue that hemispheric differences during metaphor processing could be predicted on the basis of the linguistic nature of the metaphor.

5.5 Conclusions

The present study was designed to investigate further sense-relatedness effects for ambiguous words used in context. The study also aimed to test the hypothesis that polysemous puns might be processed bilaterally whereas homonymous puns might require exclusively LH processing resources. The results replicated sense-relatedness effects for ambiguous words used in context suggesting that polysemous and homonymous words are processed

differentially possibly as a consequence of differential mental representations of their senses/meanings. The study also replicated the finding that during automatic processing puns motivated by the two senses of polysemous words were more taxing relative to puns motivated by the two meanings of homonyms. Most importantly, however, consistent with the RH hypothesis for non-literal language processing, the study suggests that puns were processed faster in the RH than the LH. It was argued that the RH involvement reflects the relative difficulty of processing puns whose multiple interpretations are all valid and plausible utterances.

5.6 Hemispheric asymmetries for pun processing – Main findings

The studies in Chapters 4 and 5 of this thesis were designed to explore the hypothesis that previous investigations of hemispheric asymmetries during pun processing failed to provide strong evidence in support of the RH hypothesis partly because the internal semantics of puns had not been taken into consideration. The results were consistent with our hypothesis. The overall pattern of the data strongly pointed to the conclusion that increasing the cognitive load during pun processing increases the RH involvement in that process. The studies pointed to the assumption that the two factors that increase cognitive load for pun processing are the differential mental representations for the words and phrases that motivate the puns, and the degree of plausibility of the two utterances conveyed by the puns.

In Chapter 4 (Experiments 5 and 6) we investigated the hemispheric differences in the time-course of double meaning activation for puns motivated by the inherent ambiguity between the literal and idiomatic meanings for non-decomposable and decomposable idioms. Across both ISIs (0ms and 750ms), the results revealed clear decomposition effects both for idioms in single-meaning and double-meaning consistent contexts. Most importantly, however, the results indicated that decomposition effects in double-meaning punning contexts were further modified by the hemisphere presentation. To be more specific, non-decomposable puns, which are triggered by the intentional ambiguity between the literal and idiomatic meanings of non-decomposable idioms, showed consistently LH involvement. On the other hand, decomposable puns, which are triggered by the intentional ambiguity between the literal and idiomatic meanings of decomposable idioms, consistently exhibited bilateral processing (i.e., each hemisphere was equally fast in the processing of this type of puns). We argued that additional processing recourses were recruited from the RH only for decomposable puns mainly due to the non-lexicalised status of the idiomatic meanings of this type of idioms. In particular, there is little need for the idiomatic meanings of decomposable idioms to be

lexicalized as they are semantically close to and possibly derived on-line from the literal meanings. However, when literal and idiomatic meanings were used in a contrastive punning context they had to be considered similar enough so that one is derived from the other but at the same time distinct enough so that the punning context worked as it was intended. Therefore, we might conclude that the closer two meanings are, the harder they will be processed in a punning context that mainly aims to juxtapose two or more meanings for humorous effects resulting in some RH recruitment in the process.

In Chapter 5 (Experiments 7 and 8) we aimed to investigate further hemispheric differences in the time-course of double meaning activation for puns motivated by the inherent ambiguity between the dominant and subordinate meanings/senses of ambiguous words. The results from Experiment 7 (ISI: 0ms) revealed significant sense-relatedness effects for ambiguous words used in biasing contexts indicating that polysemous and homonymous words followed a different pattern of meaning activation. The pattern of results was consistent with the one obtained from Experiment 3 that used the same materials but the targets were centrally presented (see Chapter 3) (but cf. Klepousniotou, 2005b who did not report sense-relatedness effects for ambiguous words used in context). Furthermore, the results from Experiment 7 demonstrated that the two hemispheres are differentially employed during the very early stages of meaning activation for polysemous and homonymous words. Consistent with Klepousniotou et al (2012), the RH showed preferential processing for the subordinate senses of polysemous ambiguous words, which was not observed for the subordinate meanings of homonyms. The current experiment expands the findings by Klepousniotou et al (2012) by providing evidence that preferential RH involvement in the processing of the subordinate senses of polysemous words only is also attested for ambiguous words used in sentence contexts. However, similar hemispheric differences were not observed in Experiment 8 (ISI: 750ms) suggesting that sense-relatedness effects might be a function of automaticity of processing. Although the results from Experiment 8 did not indicate sense-relatedness effects for ambiguous words used in context, the data suggest that, irrespective of sense-relatedness effects, the RH processes faster double-meaning consistent contexts (or puns) and subordinate-meaning consistent contexts relative to dominant-meaning consistent ones (while the LH processes all three contexts equally well). This result clearly highlights the RH's involvement for pun processing, which is consistent with the RH hypothesis for non-literal language processing (Giora, 2007). We argue that the RH involvement for puns in the present study was induced by the greater cognitive effort required for the processing of puns motivated by the multiple meanings/senses of ambiguous words. It could be speculated that

the greater cognitive effort in this study was driven by the necessity to process simultaneously two equally plausible utterances that were conveyed by these puns.

Therefore, the overall pattern of results from the two studies in Chapters 4 and 5 strongly supports the hypothesis that the internal semantics of puns is an important predictor of preferential RH involvement in pun processing. In sum, the results are consistent with the assumption that RH is preferentially used in the processing of non-literal language (Giora, 2007). Furthermore, the results from the two studies also provided experimental evidence in support of the cognitive continuum hypothesis proposed recently by Faust and Kenett (2014). On the basis of experimental investigations of metaphor processing, the cognitive continuum hypothesis suggests that the novelty and creativity of the language triggering metaphors is an accurate predictor for hemispheric asymmetries for processing metaphors. In particular, the more novel and less conventional the language motivating the metaphor is, the more taxing the processing will be, which predicts greater involvement of the RH. The results from the current two studies expand the understanding of the cognitive continuum hypothesis by providing experimental evidence from another type of non-literal language, namely puns. It is argued that the more similar and plausible the two interpretations of puns are to each other, the more taxing the processing will be, which in turn will predict greater involvement of the RH. Currently, we speculate that plausibility might be the more important variable to induce greater cognitive load in the processing of puns, however further research is required in this field in order to support such an assumption.

It has become evident that the results from the four experiments using the divided visual field (DVF) priming paradigm presented in this part of the thesis revealed main and interaction effects which were not observed in the four experiments that used the semantic priming paradigm with central presentation of targets. We argue that this is because the divided visual field methodology is a more sensitive paradigm that can reveal a more detailed and fine-grained picture of the time-course of meaning activation. Given the main logic behind the DVF methodology, namely that stimulus presented in one of the visual fields is initially processed by the counter-lateral hemisphere, as well as the ample evidence that the two hemispheres specialize in processing different aspects of language (e.g., Jung-Beeman, 2005; Simpson and Burgess, 1988; Titone, 1998), we can assume that compared to priming with central presentation for targets, the divided visual field priming paradigm is better suited to provide a more detailed picture of the time-course of meaning activation and reveal more fine-grained distinctions between conditions. In other words, the divided visual field paradigm is a more

sensitive priming paradigm than priming with central presentation for targets because it induces processing that is initially carried out by one of the hemispheres hence revealing effects which will be otherwise obscured in tasks that encourage inter-hemispheric processing.

The last experimental chapter of this thesis continues to investigate the time-course of double meaning activation in pun processing and the implications it has for the cognitive costs spent in that process. Chapter 6 expands the results we have already presented so far by employing a different methodology, namely we collected electrophysiological data in order to provide a more precise and accurate temporal picture of the time-course of double-meaning activation in puns.

Chapter 6. Neural correlates of pun processing – an EEG/ERP investigation

6.1 Introduction

As discussed in Chapters 1, 2 and 3 of this thesis, most behavioural investigations yield data that support one of three leading models. The *standard pragmatic approach* (Grice, 1975) is a hierarchical, or modular, approach that argues that non-literal language is processed in a serial manner. Such models assume that the literal meaning of a non-literal utterance is computed first, and only if perceived to be deviant and ill-formed, it then initiates a search for the intended non-literal meaning. The corollary of such a view is that non-literal meanings are processed in a qualitatively different way from literal language and the implication is that non-literal language processing is inherently harder due to the initial perceived mismatch between literal and intended non-literal meanings. Conversely, the *direct access model* (Gibbs, 1994) does not see non-literal language as deviant and ill-formed. Rather, according to that model suitably constraining contexts can guide access to non-literal meanings directly and independently from their literal meanings. Hence, non-literal language is not processed differently from literal language implying that its processing is not inherently more difficult. In an attempt to reconcile these two extreme views, the middle-ground position of the *graded salience hypothesis* was introduced (henceforth GSH; Giora, 2012). The GSH assumes that non-literal language processing is carried out in accordance with two operations that run independently from one another. Firstly, consistent with modular approaches, non-literal language processing is sensitive to the salience of language units. Giora (2012) argues that 'salience' is an inherent feature of language units that is a function of their familiarity, conventionality and meaning dominance; in other words, salience is related to other lexical factors known to affect language processing. Giora (2012) further argues that the concept of 'salience' is not an all-or-nothing feature as some linguistic items are more salient than others, i.e., they are more familiar, more conventional and more frequent. The processing implication is that more salient language will be accessed before less salient language. Secondly, consistent with non-modular approaches, the GSH argues that context is an additional factor operating during non-literal language processing. However, since both context and salience operate independently this hypothesis assumes that even strongly biasing contexts cannot bypass the activation of the most salient but contextually inappropriate meanings.

According to Kutas (2006), research on non-literal language processing could be informed and expanded by employing neurophysiological methods of investigation and by considering

neurocognitive models of language processing (Baggio and Hagoort, 2011; Brouwer and Hoeks, 2013**;** Friederici, 2002, 2011; for a general discussion on main neurocognitive models see Brouwer and Hoeks, 2013, and Kuperberg, 2007). Although extensive discussion of these models is beyond the scope of the present chapter, the most relevant aspect is that the core of all models relies on cognitive processes reflected in two major ERP components, namely the N400 and the P600. The N400 is a negative deflection in the ERP signal that peaks around 400ms post-stimulus onset. Most generally, the N400 component is held to reflect retrieval of word meanings and local semantic integration (e.g., Baggio and Hagoort, 2011; Van Berkum, 2009), semantic integration (Friederici, 2011), or semantic congruency (Kutas and Hillyard, 1980). Modulations in the amplitude of this deflection indicate the ease of accessing meaning and mapping of the incoming words onto the semantic structure of the sentence (De Grauwe, Swain, Holcomb, Ditman, Kuperberg, 2010; Kutas and Federmeier, 2000; Lau, Phillips, Poeppel, 2008; for a review of the N400 ERP component see Kutas and Federmeier, 2011). In particular, the more negative the N400 amplitude of an incoming word is (related to a neutral baseline), the more difficult its retrieval, integration and mapping have been. On the other hand, the P600 is a positive deflection in the ERP signal that peaks around 600ms post-stimulus onset. This component is held to reflect syntactic processing, and modulations of the P600 amplitude have been observed in response to grammatical violations such as lack of subject-verb agreement (Hagoort, Brown, Groothusen, 1993), violations of grammatical gender in Dutch (Hagoort and Brown, 1999), as well as structural repair and re-analysis (Friederici, 2002). In particular, the more positive the amplitude of the P600 component, the more disrupted the syntactic integration processes are assumed to be. Even though a neat one-to-one mapping between the semantic N400 and syntactic P600 effects has been recently challenged (e.g., Brouwer and Hoeks, 2013), there is a general consensus that language comprehension proceeds along two competing but possibly parallel processing streams. The first one is a semantic memory-based mechanism that is for the greatest part captured by the N400 component during which we constantly compare and update lexical and categorical relationships pre-stored in memory. Additionally, a second combinatorial stream also operates that is sensitive to overall morpho-syntactic and thematic constraints for the greatest part captured by the P600 component during which we build an overall (finalised) interpretation of an utterance (De Grauwe et al., 2010; Kuperberg, 2007).

The N400 and the P600 components have been used as dependent measures mostly in investigations on metaphor processing. For example, consistent with the standard pragmatic approach, N400 amplitudes time-locked to the onset of sentence-final words have been found

to be more negative after metaphoric sentence completions relative to literal baselines (Coulson and Van Petten, 2002; Coulson and Van Petten, 2007; Lai et al., 2009; Pynte et al., 1996). In contrast, the results for the P600 component in these studies are not so consistent. In particular, while Pynte et al. (1996) did not find any metaphor-related P600 effects, Coulson and Van Petten (2002; 2007) reported larger P600 effects for the metaphorically completed sentences compared to literal controls. Furthermore, a few studies found support for predictions derived from the GSH (Giora, 2012) reporting graded N400 effects for literal, strongly salient and weakly salient figurative language (Arzouan et al., 2007b; De Grauwe et al., 2010; Laurent et al., 2006). Finally, Iakimova et al. (2005) failed to find differences in the modulations of both the N400 and P600 amplitudes of literal and highly conventionalized dictionary metaphors, which was argued to support the direct access model. In addition to investigating metaphoric non-literal language, a few studies explored irony-related N400 and P600 effects (Regel et. al., 2010; Regel, Meyer, Gunter, 2014; Spotorno, Cheylus, Van Der Henst, Noveck, 2013). However, none of these studies report differential amplitudes for literal and ironic statements within the N400 time window. On the other hand, all three studies report that within the P600 time window ironic utterances proved more difficult as they elicited larger P600 effects.

Although puns are considered an example of figurative language, the experimental literature on pun processing is rather limited (Coulson and Severens, 2007; Goel and Dolan, 2001; Kana and Wadsworth, 2012; Sheridan et al., 2009). Of these, only Coulson and Severens' (2007) study monitored event-related brain potentials within a half-field semantic priming paradigm. In their study, experimental puns were followed by two related probe words – one was highly related to the pun, while the other was only moderately related. Control puns were followed by unrelated probe words. In order to investigate the time-course of meaning activation during pun processing, the authors observed amplitude modulations time-locked to the probe words in two time windows, namely 300-600ms and 600-900ms post-probe presentation. Coulson and Severens (2007) conducted two experiments. In the first experiment, the aural presentation of puns was immediately followed by the visual presentation of the probe word (ISI: 0ms) tapping into automatic language processing. In the second experiment, the presentation of the probe word was delayed by 500ms (ISI: 500ms) tapping onto the late attention-driven language processing. In Experiment 1, the results for the 300-600ms time window indicated that in the Left Hemisphere (LH) both related targets exhibited less negative N400 amplitudes relative to unrelated probes. However, in the Right Hemisphere (RH) only the highly related probe words showed a trend for reduced N400 effects relative to the unrelated

probes. The results for the 600-900ms time-window (intending to capture the P600 component) indicated that in the LH both related probes elicited more positive amplitudes relative to the unrelated probe, whereas in the RH only the highly related probes elicited more positive amplitudes. Therefore, the authors concluded that during the early stages of pun processing there is a LH advantage for processing puns as only the LH showed processing of both highly related and moderately related probes (the RH processed only the highly related probe words).

In Experiment 2, the results for the 300-600ms time window (to capture N400 effects) indicated that in both hemispheres the highly related and the moderately related probes showed reduced N400 effects. Additionally, the results for the 600-900ms positivity (to capture the P600 effects) suggested that again in both hemispheres the highly related and the moderately related probes showed more pronounced P600 effects. Coulson and Severens (2007) concluded that during the later stages of processing puns did not exhibit hemispheric asymmetries, i.e., both hemispheres processed puns equally well. Thus, the overall pattern of activation obtained from the two experiments of Coulson and Severens' (2007) study suggests that the right hemisphere did not show activation for the moderately related targets in the early stages of processing but activation rose during the later stage of language processing. The researchers concluded that the study is consistent with previous results that suggested the slower rise time in the RH for less salient meanings (e.g., Simpson and Burgess, 1988). While clearly the language dominant LH showed processing advantage during automatic processing, the results Coulson and Severens (2007) present indicate bilateral pun processing during a later stage of processing. Although they did not highlight this finding in their discussion, we suggest that the lack of hemispheric preferences during the later processing stage points to some RH involvement during pun processing.

Most relevantly for the current investigation, we conclude that Coulson and Severens's (2007) study shows pun-related attenuated N400 effects and more pronounced late positivity effects. In particular, the N400 effects showed priming effects for the two related probes, whereas the more positive amplitudes in the later time window could suggest some processing difficulty for the combinatorial processing mechanism. One might be tempted to conclude that the priming effects in the N400 time window suggest that the pun context facilitates the semantic memory-based mechanism, while the more pronounced amplitudes in the P600 time window suggest processing costs for the syntactic combinatory mechanism. However, as discussed in greater detail in Section 1.3.2, such a conclusion would be premature on the basis of Coulson

and Severens' (2007) study alone since their experimental design used only one type of context, namely the punning context. Since all their primes were pun sentences the study does not have a control non-pun context condition for baseline comparisons. Additionally, there were no unrelated targets after the experimental pun condition to function as a baseline to which to compare the activation levels of the two related targets. Therefore, the N400 and P600 effects reported by Coulson and Severens (2007) might be the result of the degree of relatedness of their probes to the pun-primes. In other words, instead of context effects Coulson and Severens (2007) might have tapped into relatedness effects caused by the three different types of targets, the highly related, moderately related and unrelated probes (which followed non-experimental puns only). In order to overcome this issue, the design of the current study includes a single-meaning (non-pun) context to function as a baseline control condition. Furthermore, Coulson and Severens (2007) report that most of their pun sentences are homographic (i.e., sentences in which one word has more than one meaning such as *The inventor of a hay baling machine made a bundle.*), but a closer look at their materials reveals that sometimes the word that has more than one meaning is an ambiguous word (e.g., *In England, dog food is sold by the pound. or Old lawyers never die, they just lose their appeal.*) while other times the word is actually a part of an idiomatic expression (e.g., *I know a lingerie buyer who gave his wife the slip*. or *A reporter was at the ice cream store getting the scoop.*). Additionally, Coulson and Severens (2007) report that other pun sentences from their experimental set are ideophonic (i.e., meanings evoked by the pun are related to similar but not identical word forms such as *Coal mines that aren't deep enough will be under-mined.*). Thus, by using different language types to motivate the puns in their study, Coulson and Severns (2007) cannot differentiate between the processing effects related to double meaning utterances and those related to the linguistic items that motivate the double meanings in puns. For example, there is evidence from the lexical ambiguity literature that all meanings of an ambiguous word are exhaustively accessed (Swinney, 1979), whereas the literature on idiom processing suggests that idiomatic meanings are activated approximately 300ms post-idiom presentation (Cacciari and Tabossi, 1988). In order to fully investigate the double meaning nature of puns and explore the role of the punning context, experimental designs and materials in particular, need to be carefully controlled for the underlying motivating nature of the double meanings in puns and tease apart the processing effects related to puns and processing effects related to the language that motivates puns. Also, in addition to the other flaws of Coulson and Severens' (2007) study that we discussed in Section 1.3.2 and tried to rectify in our DVF studies, there is a further concern with Coulson and Severens' design that is

particularly relevant for this EEG/ERP experiment. Namely, the researchers recorded electrical activity from 29 electrode sites and conducted their analyses on single electrode data. It has been known for a long time now that grouping single electrode sites in clusters improves the ERP signal and reduces the family-wise statistical errors (Oken and Chiappa, 1986). Therefore, in order to strengthen the ERP signal in important areas, we grouped our electrodes in 6 clusters in the LH and the mirror arrangement of further 6 clusters in the RH. There are two frontal clusters (lateral and medial), two central clusters (lateral and medial) and two posterior clusters (lateral and medial). We provide our rationale for this split in the Methods section 6.2.1 below.

The present experiment aimed to investigate double meaning consistent puns motivated by idiomatic expressions (e.g., *A reporter was at the ice cream store* ***getting the scoop****.).* As we already discussed in Chapters 1, 2 and 4 on-line idiom processing is affected by idiom decomposition effects (see Section 1.1.3 for a detailed description of the Idiom Decomposition Hypothesis and idiom decomposition effects). Thus, taking into consideration idiom decomposition effects, the present experiment aimed to investigate when and how contextual information affects the processing of utterances that convey two simultaneously intended meanings, i.e., puns. Both decomposable and non-decomposable idioms were used as primes in single meaning idiomatic sentences and double-meaning punning sentences that were immediately followed by a target word (ISI: 0ms). Targets were related to (i) the literal meaning of the idiom's content word (literal targets), (ii) the idiomatic meaning (idiomatic targets), or (iii) were unrelated (baseline control). We focused both on the N400 and P600 amplitudes of the brain signal that were time-locked to the onset of the target words.

According to the standard pragmatic approach (Grice, 1975), the double-meaning consistent punning context is expected to incur additional processing costs relative to the single-meaning consistent idiomatic contexts. It is expected that the processing costs would be evident in both N400 and P600 pun-related effects. More specifically, the literal and idiomatic targets after punning contexts are expected to produce more negative amplitudes in the region of the N400 time window and more positive amplitudes in the region of the P600 time window relative to the amplitudes for the same targets after single-meaning consistent idiomatic contexts. The graded salience hypothesis (GSH; Giora, 2002; 2012) would also predict pun-related N400 effects. According to that hypothesis, the double-meaning consistent contexts would lead to competition between lexically coded salient meanings (the idiomatic ones) and the more contextually driven non-salient meanings (the literal meanings). Additionally, the GSH would

also predict pun-related processing difficulties in the P600 time window as the combinatorial mechanism would find it hard to establish a finalised coherent statement. Thus, although for different reasons, both the standard pragmatic approach and the graded salience hypothesis predict processing costs for the double-meaning contexts in both time windows. Conversely, the direct access model (Gibbs, 1994) does not predict differences in either the N400 or the P600 components between single meaning and double-meaning contexts as it argues that non-literal language is accessed directly without incurring additional processing effort. More specifically, the literal and idiomatic targets after punning contexts are expected to produce equally negative amplitudes in the region of the N400 time window and equally positive amplitudes in the region of the P600 time window relative to the amplitudes for the same targets after single-meaning consistent contexts.

6.2 Experiment 9

6.2.1 Method

Participants:

Thirty native speakers of English (11 male) with an average age of 23.6 years (range 18-33) and an average of 15.6 years of education (range 13-20) took part in the experiment for remuneration. All participants were right-handed, as assessed according to the Handedness Inventory by Briggs and Nebes, 1975, with normal or corrected to normal vision and no history of either neurological or language impairments. The study received approval from the Ethics Committee of the School of Psychology, University of Leeds (Certificate of ethical approval #13-0006; Appendix 1(b)).

Design and stimulus material

The study had a within-subjects design with 6 factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Decomposition (two levels: decomposable idioms, non-decomposable idioms), Context (two levels: double-meaning consistent, single-meaning consistent) and Target type (three levels: literally-related, idiomatically-related, unrelated). We used the same materials as in the earlier behavioural study with central presentation for targets that aimed to investigate processing of puns motivated by decomposable and non-decomposable idioms (see Section 2.2.1 for a detailed description of the materials and pre-tests of the stimuli).

Procedure

Stimuli were counterbalanced over two lists (List A and List B) and the items in each list were pseudo-randomised so that no three stimuli of the same type occurred consecutively. Participants had to attend one testing session in which they completed both lists. The order of the two lists was counterbalanced for participants. Participants were tested individually in a single session lasting approximately one and a half hours. Stimuli were presented aurally through computer loudspeakers. Each trial began with the visual presentation of a series of exclamation points (!!!) for 1000ms, which was a signal for the participant to rest their eyes and blink. After the presentation of the exclamation points, a fixation point (+) was presented for 200ms to signal that the trial was about to begin. After the fixation point, the prime was presented aurally for the duration of 3-5ms. Immediately after the end of the sentence (ISI: 0ms), the target was presented for 500ms. After a delay of 700ms, a question mark (?) appeared for 1500ms during which time participants had to make a lexical decision about the target (decide whether or not it was a real word in English) by pressing the relevant mouse-button. Participants were instructed to respond as accurately as possible; accuracy and reaction times (in ms from the onset of the "?") were recorded. After the response (or at the end of 1500ms if the participant did not respond), there was a delay of 100ms before the next trial started (see Figure 20). The experimental session was preceded by a practice session comprising 11 trials, which was repeated until participants could perform the task and procedure with no errors (usually two practice sessions were required).

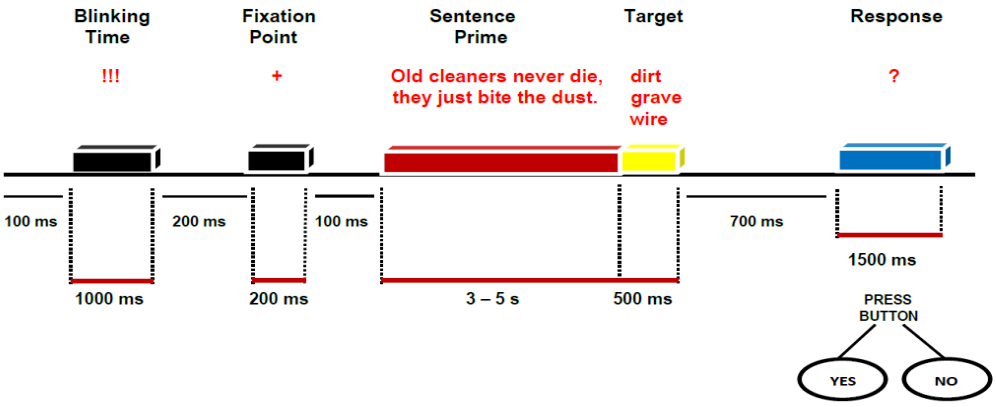

Figure 20 A single trial procedure showing timings of each stage.

EEG recording and data processing

EEG was recorded (Neuroscan Synamps2) from 60 Ag/AgCl electrodes that were embedded in a cap based on the extended version of the International 10-20 positioning system (Sharbrough et al., 1991) and fitted with QuikCell liquid electrolyte application system (CompumedicsNeuroscan). Additional electrodes were placed on the left and right mastoids. Data were recorded using a central reference electrode placed between Cz and CPz. The ground electrode was positioned between Fz and Fpz. To monitor eye movements electro-oculargrams (EOGs) were recorded using electrodes positioned either side of the eyes, and above and below the left eye. At the beginning of the experiment electrode impedances were below 10 kΩ. The analogue EEG and EOG recordings were amplified (band pass filter 0.1 to 100Hz), and continuously digitised (32-bit) at a sampling frequency of 500 Hz.

Data were processed offline using Neuroscan Edit 4.3 software (CompumedicsNeuroscan). Data were filtered (0.1-40Hz, 96 dB/Oct, Butterworth zero phase filter), inspected visually and segments contaminated by muscular movement marked as bad. The data sets of 5 participants had to be excluded due to too much muscular movement that made the data very noisy. The effect of eye-blink artifacts was minimised by estimating and correcting their contribution to the EEG using a regression procedure that involves calculating an average blink from 32 blinks for each participant, and removing the contribution of the blink from all other channels on a point-by-point basis. Data were epoched between -100 and 900ms relative to the onset of the experimental targets (brain response to the pseudo-word targets was not analysed) and baseline corrected by subtracting the mean amplitude over the pre-stimulus interval. Epochs were rejected if participants did not make a response within the allocated time (during presentation of the "?"), or if they made an incorrect response (mean = 2.5%) or when drift (absolute difference in amplitude between the first and last data point of each individual epoch) was greater than 100 µV. Data were then re-referenced to the average of left and right mastoid recordings and smoothed over nine points so that each sampling point represents the average over the four previous and four subsequent points. Finally, further epochs were rejected when amplitude on any channel exceeded ±75 µV. Average ERPs were calculated for the target words in each of the 12 experimental conditions (2 context x 2 decomposition x 3 target types) and grand averages calculated across participants.

EEG data analysis

To assess the processing of different types of idioms (non-decomposable and decomposable) in the two types of context (single-meaning and double-meaning consistent), we analysed priming effects indexed by the N400 and P600 brain response. For both N400 and P600 the amplitude of the ERP brain responses to the target words was compared between experimental conditions with repeated measures Analyses of Variance (ANOVAs) using the Greenhouse-Geisser correction for inequality of variance where appropriate (data are reported with corrected p values). Based on previous studies and inspection of the data, statistical analyses were performed on mean amplitudes over the following two time windows: (i) 350-450ms, chosen to capture the maximum of the N400, and (ii) 470-620ms, chosen to capture the maximum of the P600. ANOVAs were performed on data from all lateral electrodes (excluding the midline) grouped into 12 clusters (see Figure 21). The repeated-measures ANOVA included the factors of Hemisphere (left vs. right), Location (frontal vs. central vs. posterior), Region (lateral vs. medial), Decomposition (non-decomposable idioms vs. decomposable idioms), Context (idiomatic single-meaning consistent vs. punning double-meaning consistent) and Target Type (literal vs. idiomatic vs. unrelated). The factors of Hemisphere, Decomposition, Context and Target type are necessary for the main hypotheses in this investigation. However, the factors of Location and Region are also necessary in the context of the relevant EEG/ERP literature. In order to be consistent with the EEG literature on idiom processing, the frontal vs posterior distinction within the factor of Location is peremptory (e.g., Canal et al., 2010; Rommers et al., 2013). Evidence suggests that the topographic distribution of idiom-related ERP effects changes depending on the idiom recognition point with more anterior effects *before* recognition and more posterior effects *after* recognition. If only non-decomposable idioms have lexicalised idiomatic meanings we might assume that they will be recognised faster, hence we expect earlier ERP effects for non-decomposable idioms in posterior locations. Furthermore, the relevance of this distinction for idiom processing is supported by the fMRI literature on idiom processing (e.g., Mashal et al., 2008) and more generally, by the EEG/ERP literature on non-literal language processing (e.g. Regel et al., 2010). Crucially, since Coulson and Severens (2007), which is the study whose findings we are trying to expand, reported P600 pun-related effects in centro-parietal locations, it is crucial that we have a separate grouping for more central electrode sites to isolate the central regions as potentially relevant to pun processing. Moreover, Regel et al. (2010) reported P600 irony-related effects in centro-parietal locations hence it could be assumed that this location might be engaged in non-literal language processing more

generally. Lastly, Balconi and Amenta (2010) reported a three-way split between frontal, central and posterior locations indicating their importance for metaphor processing. Therefore, given the lack of extensive literature specifically focusing on pun processing and our attempt to relate our findings both to the literature on idiom processing and that on non-literal language processing the factor of Location (with the three levels frontal, central and posterior) is necessary.

As far as the factor of Region is concerned, we kept the distinction between lateral and medial sites for two reasons. Again this distinction is relevant in the ERP research on non-literal language processing since most effects are observed in medial regions (e.g., Coulson and Van Petten, 2007 for lateral vs. medial distinction in metaphors; Ferretti et al., 2007 for lateral vs. medial distinction in proverbs). Additionally, ERP research on polysemous and homonymous words using the same electrode clusters (MacGregor et al., 2015) reported that subordinate meanings of unbalanced homonyms engaged predominantly medial sites, whereas dominant meanings of the same homonyms engaged predominantly lateral sites. Furthermore, a similar split between the subordinate and dominant senses of polysemous words was also reported (especially for metonymic polysemous words). Thus, it could be assumed that medial sites engage predominantly subordinate meanings, while lateral sites seem to engage more dominant meanings. To conclude, given the evidence from the ERP literature on non-literal language processing that most effects are observed in medial sites and the parallel evidence that subordinate meanings of ambiguous words also engage medial sites, we feel justified in using the medial vs. lateral distinction within the factor of Region in an investigation on puns, which are a type of non-literal language that relies on pre-activated subordinate meanings[2].

Significant interactions involving the experimental conditions (Decomposition, Context and Target type) were followed up with further ANOVAs and post-hoc (Newman-Keuls) tests where appropriate. Only significant effects reflecting priming (effect of Target Type) and involving the experimental factors of interest (Decomposition and Context) are reported. Where

[2] According to compositional theories of idiom processing that assume a literal-first processing of idiomatic meanings, the subordinate meanings of idioms will be the idiomatic ones. However, according to lexical theories of idiom processing that assume a direct access to idiomatic meanings, the subordinate meanings will be the literal ones. Furthermore, consistent with the results from Chapter 2 and Chapter 4, we argue that processing decomposable idioms follow the tenets of compositional theories thus the subordinate meanings of these idioms will be the idiomatic ones. Conversely, processing non-decomposable idioms follow the tenets of lexical theories thus the subordinate meanings of these idioms will be the literal ones. Given these differences in the theories on idiom processing, and the evidence from past literature on the involvement of medial vs lateral regions in the processing of subordinate vs dominant meanings, it is imperative to include the factor of Region in the EEG/ERP analyses.

appropriate the Greenhouse-Geisser correction was applied and original degrees of freedom with the corrected *p*-values are reported.

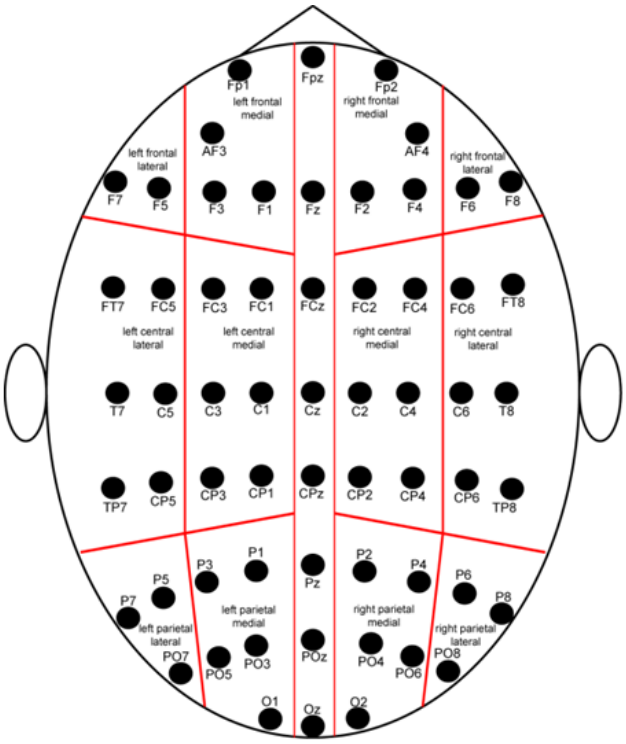

Figure 21 Schematic layout of the 60 electrodes from which data were recorded showing the 12 electrode clusters used for the analyses (see labels).

6.2.2 Results - 350-450ms

The data were subjected to a repeated measures ANOVA with six factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Decomposition (two levels: decomposable and non-decomposable idioms), Context (two levels: double-meaning consistent pun context, single-meaning consistent idiom context) and Target type (three levels: literally-related, idiomatically-related and unrelated). The analysis revealed a robust six-way interaction effect [$F(4,96) = 6.895$, MS = 3.181, $p<0.0006$, $\eta_p^2 = 0.223$]. To explore the data fully repeated measures analyses of variance were conducted separately for the non-decomposable and decomposable idioms. For each new ANOVA, main and interaction effects will be reported only if they (i) involve at least one of the experimental factors, namely Context and Target type, and (ii) have survived after the Greenhouse-Geisser correction was applied.

ERP data: 350-450ms for non-decomposable idioms

The data were subjected to a repeated measures ANOVA with five factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Context (two levels: double-meaning consistent pun context, single-meaning consistent idiom context) and Target type (three levels: literally-related, idiomatically-related, unrelated). The analysis revealed a significant main effect of Context [$F(1,24) = 4.601$, MS = 102.086, $p<0.042$, $\eta_p^2 = 0.161$]. Additionally, there were significant three-way interactions of Hemisphere, Location and Context [$F(2,48) = 4.867$, MS = 6.492, $p<0.015$, $\eta_p^2 = 0.169$], Location, Region and Context [$F(2,48) = 6.847$, MS = 4.917, $p<0.005$, $\eta_p^2 = 0.222$] and Hemisphere, Region and Target type [$F(2,48) = 8.308$, MS = 3.130, $p<0.001$, $\eta_p^2 = 0.257$]. Furthermore, there were significant four-way interactions of Hemisphere, Location, Region and Target type [$F(4,96) = 2.808$, MS = 0.987, $p<0.038$, $\eta_p^2 = 0.105$] as well as Hemisphere, Location, Context and Target type [$F(4,96) = 3.516$, MS = 1.296, $p<0.029$, $\eta_p^2 = 0.128$]. Most importantly, the five-way interaction of all independent factors was revealed to be significant [$F(4,96) = 6.933$, MS = 2.641, $p<0.0003$, $\eta_p^2 = 0.224$].

As the five-way interaction gives the most detailed picture of the data, we explored it further by running post-hoc tests (Newman-Keuls, $p<0.05$). In the left hemisphere in both frontal medial and lateral regions, after idiomatic contexts neither literal nor idiomatic targets showed N400 effects relative to the baseline ($p=0.976$ and $p=0.848$; $p=0.932$ and $p=0.230$ respectively), whereas after double-meaning consistent contexts, both literal and idiomatic targets showed reduced N400 amplitudes relative to the baseline ($p<0.003$ and $p<0.053$; $p<0.003$ and $p<0.02$ respectively) indicating that in frontal medial and lateral regions the double-meaning consistent context facilitated access to both meanings.

In central medial and lateral regions, after idiomatic contexts neither literal nor idiomatic targets exhibited N400 effects relative to the baseline ($p=0.405$ and $p=0.999$; $p=0.955$ and $p=0.925$ respectively). After double-meaning consistent contexts, medially only the idiomatic targets showed reduced N400 effects relative to the baseline ($p<0.02$); the literal targets showed similar N400 effects as the unrelated targets ($p=0.452$). In lateral regions, however, both literal and idiomatic targets showed reduced N400 amplitudes relative to the baseline ($p<0.032$ and $p<0.007$ respectively) indicating that in central lateral regions the double-meaning consistent context facilitated access to both meanings.

Finally, in posterior medial regions, after idiomatic contexts the idiomatic target did not show reduced N400 effects relative to the unrelated targets (p=0.959) while the literal targets showed increased N400 effects relative to the unrelated baseline (p<0.03) indicating possible interference effects caused by meaning competition between the idiomatic and literal meanings. After double-meaning consistent contexts, only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.003); the literal targets showed similar N400 effects as the unrelated targets (p=0.195) (see Figure 22 and 23 below). In posterior lateral regions, after idiomatic contexts neither literal nor idiomatic targets exhibited N400 effects relative to the baseline (p=0.997 and p=0.999 respectively), while after double-meaning consistent contexts only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.03); the literal targets showed similar N400 effects as the unrelated targets (p=0.07).

The patterns of activation for the two meanings of non-decomposable idioms in the two contexts for responses made in the Right Hemisphere showed a radically different picture. The idiomatic and double-meaning consistent contexts showed differential facilitation effects for the two meanings only in posterior lateral regions. In particular, after idiomatic contexts, idiomatic targets did not show reduced N400 effects relative to unrelated targets (p=0.574) while literal targets showed more negative amplitudes relative to unrelated targets (p<0.0001) indicating possible interference effects. After double-meaning consistent contexts both literal and idiomatic targets showed reduced N400 effects relative to the baseline (p<0.001 and p<0.03 respectively). In all the other regions and locations, neither context facilitated any of the two meanings of non-decomposable idioms.

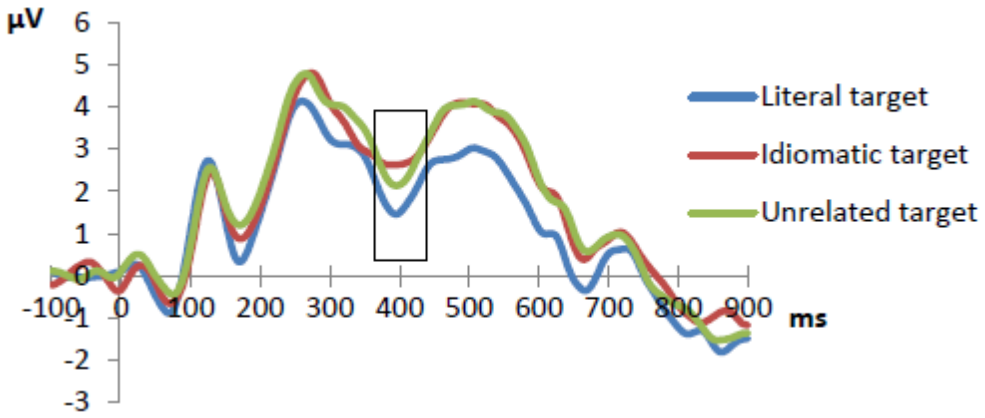

Figure 22 N400 effects (µV) for the literal and idiomatic meanings of non-decomposable idioms relative to the unrelated targets in single-meaning idiomatic contexts at P3 electrode site.

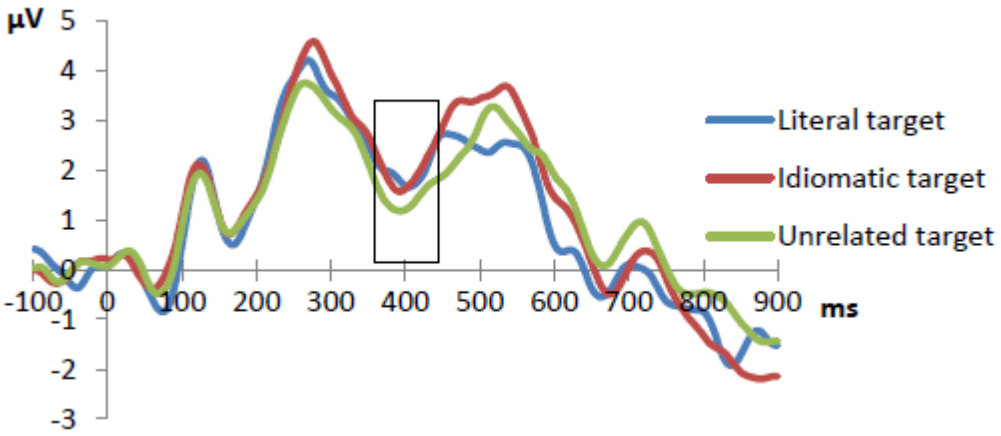

Figure 23 N400 effects (μV) for the literal and idiomatic meanings of non-decomposable idioms relative to the unrelated targets in double-meaning punning contexts at P3 electrode site.

ERP data: 350-450ms for decomposable idioms

The data were subjected to a repeated measures ANOVA with five factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Context (two levels: double-meaning consistent pun context, single-meaning consistent idiom context) and Target type (three levels: literally-related, idiomatically-related, unrelated). The analysis revealed a significant main effect of Target type [$F(2,48) = 4.841$, MS = 120.619, $p<0.0197$, $\eta_p^2 = 0.168$]. Additionally, there were significant two-way interactions of Region and Target type [$F(2,48) = 10.847$, MS = 3.035, $p<0.0001$, $\eta_p^2 = 0.311$] and Context and Target type [$F(2,48) = 3.526$, MS = 58.199, $p<0.042$, $\eta_p^2 = 0.128$]. The analyses also revealed significant three-way interactions of Hemisphere, Location and Target type [$F(4,96) = 2.997$, MS = 0.721, $p<0.034$, $\eta_p^2 = 0.111$], Location, Region and Target type [$F(4,96) = 3.156$, MS = 0.761, $p<0.023$, $\eta_p^2 = 0.116$] as well as Hemisphere, Context and Target type [$F(2,48) = 6.319$, MS = 2.709, $p<0.004$, $\eta_p^2 = 0.208$]. Finally, and most importantly, the five-way interaction of all independent factors was also found to be significant [$F(4,96) = 4.951$, MS = 1.919, $p<0.003$, $\eta_p^2 = 0.171$].

As the five-way interaction gives the most detailed picture of the data, we explored it further with post-hoc tests (Newman-Keuls, $p<0.05$). In the left hemisphere, in frontal medial and lateral regions, after idiomatic contexts neither literal nor idiomatic targets exhibited N400 effects relative to the baseline ($p=0.837$ and $p=0.992$; $p=0.089$ and $p=0.0998$ respectively). After double-meaning consistent contexts, in frontal medial regions, both literal and idiomatic

targets showed reduced N400 amplitudes relative to the baseline (p<0.001 and p<0.0002 respectively) while in lateral frontal regions only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.0004); the literal targets showed similar N400 effects as the unrelated ones (p=0.617).

In central regions, both medially and laterally, after idiomatic contexts neither literal nor idiomatic targets exhibited differential N400 effects relative to the baseline (p=0.989 and p=0.714; p=0.678 and p=0.950 respectively). After double-meaning consistent contexts in both central medial and lateral regions only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.0002; p<0.0002 respectively); the literal targets showed similar N400 effects as the unrelated targets (p=0.725; p=0.199 respectively). Thus, in central medial and lateral regions the idiomatic contexts did not facilitate either idiomatic or literal meanings, whereas the double-meaning consistent contexts facilitated access only to the idiomatic meanings.

In posterior medial regions, after idiomatic contexts only the idiomatic target showed reduced N400 effects relative to the baseline (p<0.03); the literal targets showed similar N400 effects as the unrelated targets (p=0.991). After double-meaning consistent contexts, both literal and idiomatic targets showed reduced N400 amplitudes relative to the unrelated baseline (p<0.01 and p<0.0002 respectively); the difference between the literal and idiomatic targets also reached significant levels (p<0.02) indicating that idiomatic targets showed stronger priming effects relative to literal ones (see Figures 24 and 25 below). In posterior lateral regions, after idiomatic contexts neither literal nor idiomatic targets exhibited differential N400 effects relative to the baseline (p=0.514 and p=0.415 respectively), while after double-meaning consistent contexts only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.0002); the literal targets showed similar N400 effects as the unrelated targets (p=0.08).

The activation for the two meanings of decomposable idioms in the two contexts for responses made in the Right Hemisphere showed very similar patterns. In frontal medial regions, after idiomatic contexts neither literal nor idiomatic targets exhibited N400 effects relative to the baseline (p=0.948 and p=0.567 respectively) whereas after double-meaning consistent contexts, both literal and idiomatic targets showed reduced N400 amplitudes relative to the baseline (p<0.0003 and p<0.0002 respectively). For frontal lateral regions, after idiomatic contexts the idiomatic meaning showed similar N400 effects to those obtained for the unrelated baseline (p=0.872) whereas literal meanings showed more negative amplitudes for

the N400 component relative to the unrelated baseline (p<0.0002) possibly indicating interference effects. After double-meaning consistent contexts, both literal and idiomatic targets showed reduced N400 amplitudes relative to the baseline (p<0.0002 and p<0.0002 respectively) indicating that the double-meaning consistent context facilitated access to both meanings.

In central medial and lateral regions, after idiomatic contexts neither literal nor idiomatic targets exhibited N400 effects relative to the baseline (p=0.095 and p=0.989; p=0.712 and p=0.315 respectively). After double-meaning consistent contexts in central medial regions both literal and idiomatic targets showed reduced N400 amplitudes relative to the baseline (p<0.0002 and p<0.0002 respectively) while in central lateral regions only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.0002); the literal targets showed similar N400 effects as the unrelated targets (p=0.108).

In posterior medial and lateral regions, after idiomatic contexts again neither literal nor idiomatic targets exhibited N400 effects relative to the baseline (p=0.487 and p=0.957; p=0.512 and p=0.985 respectively). After double-meaning consistent contexts in posterior medial regions both literal and idiomatic targets showed reduced N400 amplitudes relative to the baseline (p<0.0001 and p<0.0002 respectively) while in posterior lateral regions only the idiomatic targets showed reduced N400 effects relative to the baseline (p<0.0002); the literal targets showed similar N400 effects as the unrelated targets (p=0.467).

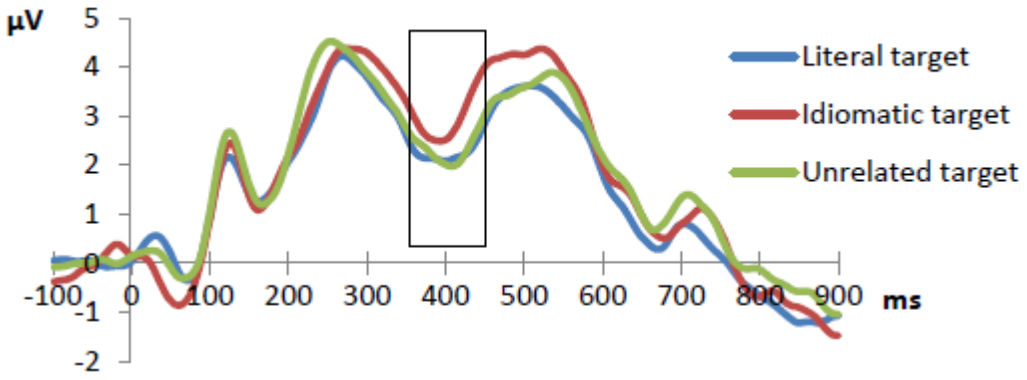

Figure 24 N400 effects (μV) for the literal and idiomatic meanings of decomposable idioms relative to the unrelated targets in single-meaning idiomatic contexts at P3 electrode site.

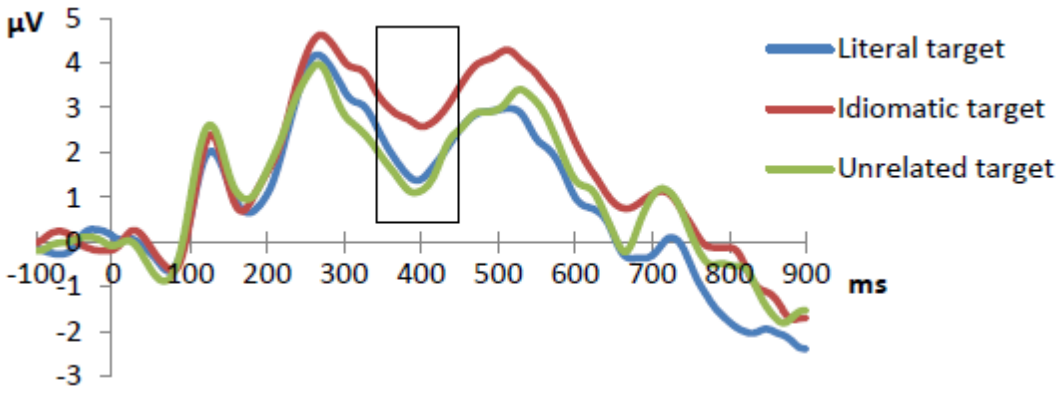

Figure 25 N400 effects (µV) for the literal and idiomatic meanings of decomposable idioms relative to the unrelated targets in double-meaning punning contexts at P3 electrode site.

6.2.3 Discussion – 350-450ms

Thus, the overall pattern for meaning access captured during the N400 time window for the two types of idioms in the two contexts leads to the following conclusions. Firstly, for non-decomposable idioms, idiomatic contexts failed to activate the idiomatic meanings due to competition effects from the dissimilar literal meanings that caused interference (especially in posterior medial sites in the left hemisphere and posterior lateral sites in the right hemisphere). For the same idioms, double-meaning consistent contexts facilitated access to both meanings in the left hemisphere in frontal and central lateral regions, and idiomatic meanings in central medial and posterior medial regions; in the right hemisphere facilitation of the two meanings was very limited and confined only to posterior lateral regions. Therefore, we tentatively conclude that processing non-decomposable puns within the time-window capturing the N400 component engages predominantly left hemisphere neural substrates.

Secondly, for decomposable idioms in idiomatic contexts, the language dominant left hemisphere facilitated access to the idiomatic meanings due to lack of any competition from the semantically similar literal meanings, although there was some evidence of competition effects between the two meanings in the right hemisphere. For decomposable idioms, double-meaning consistent punning contexts facilitated access to both meanings in the left hemisphere in frontal medial and posterior medial regions, and only idiomatic meanings elsewhere; however, in the right hemisphere, double meaning consistent punning contexts facilitated access to both meanings at further two locations, namely medial central and frontal lateral. Hence, we suggest that the double-meaning consistent contexts motivated by decomposable idioms exhibit some right hemisphere preference as the pun effect seems spread out more evenly at right hemisphere electrode sites.

In sum, irrespective of hemispheric asymmetries for the two types of puns, double-meaning consistent punning contexts facilitated the semantic memory-based cognitive mechanism, which was reflected in the data by attenuated N400 effects for the literal and idiomatic meanings (relative to the same meanings after single-meaning consistent contexts) indicating that pun processing is a highly interactive cognitive operation during which the influence of context is detected from the very early stages of processing.

6.2.4 Results - 470-620ms

The data were subjected to a repeated measures ANOVA with six factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Decomposition (two levels: decomposable idioms and non-decomposable idioms), Context (two levels: double-meaning consistent pun context, single-meaning consistent idiom context) and Target type (three levels: literally-related, idiomatically-related and unrelated). The analyses revealed a robust six-way interaction effect [*F*(4,96) =9.129, MS=5.24, *p*<0.0001, η_p^2=0.276]. To explore the data fully repeated measures analyses of variance were conducted separately for the non-decomposable and decomposable idioms. For each new ANOVA main and interaction effects will be reported only if they (i) involve at least one of the experimental factors, namely Context and Target type, and (ii) have survived after the Greenhouse-Geisser correction was applied.

ERP data: 470-620ms for non-decomposable idioms

The data were subjected to a repeated measures ANOVA with five factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Context (two levels: double-meaning consistent pun context, single-meaning consistent idiom context) and Target type (three levels: literally-related, idiomatically-related, unrelated). The analyses revealed a significant main effect of Target type [*F*(2,48) = 6.523, MS = 78.95, *p*<0.005, η_p^2 = 0.214]. There was also a significant two-way interaction of Hemisphere and Context [*F*(1,24) = 6.851, MS = 9.01, *p*<0.02, η_p^2=0.222]. There were significant three-way interactions of Hemisphere, Region and Context [*F*(1,24) = 8.249, MS = 3.97, *p*<0.008, η_p^2 = 0.256], Location, Region and Context [*F*(2,48) = 14.783, MS =12.27, *p*<0.0001, η_p^2=0.381], Hemisphere, Region and Target type [*F*(2,48) = 5.204, MS =2.81, *p*<0.01, η_p^2 =0.178], Location, Region and Target type [*F*(4,96) = 3.156, MS =1.13, *p*<0.039, η_p^2 =0.116] and Location, Context

and Target type [$F(4,96) = 3.219$, MS = 2.56, $p<0.036$, $\eta_p^2 = 0.118$]. The analysis also revealed a significant four-way interaction of Hemisphere, Location, Context and Target type [$F(4,96) = 3.644$, MS =1.39, $p<0.014$, $\eta_p^2 = 0.132$]. Finally, the five-way interaction of all independent factors was also significant [$F(4,96) = 10.985$, MS = 5.06, $p<0.00001$, $\eta_p^2 = 0.314$].

As the five-way interaction gives the most detailed picture of the data, it was explored further with post-hoc tests (Newman-Keuls, $p<0.05$). In the left hemisphere, in both frontal medial and lateral regions, after idiomatic contexts neither the literal nor the idiomatic meanings showed P600 effects relative to the unrelated baseline ($p=0.185$ and $p=0.991$; $p=0.202$ and $p=0.982$ respectively). After double-meaning consistent contexts again neither literal nor idiomatic meanings showed P600 effects ($p=0.795$ and $p=0.673$; $p=0.919$ and $p=0.487$ respectively). However, the literal meanings showed less positive P600 effects than the idiomatic meanings (medial: $p<0.007$; lateral: $p<0.008$ respectively).

In central medial regions, after idiomatic contexts, neither literal nor idiomatic meanings showed integration as both of them were treated similarly to the unrelated ones ($p=0.276$ and $p=0.999$ respectively). After double-meaning consistent contexts, again neither literal nor idiomatic meanings showed less positive amplitudes for the P600 component relative to the unrelated baseline ($p=0.657$ and $p=0.299$ respectively). However, literal meanings of non-decomposable idioms showed less positive P600 effects than idiomatic meanings ($p<0.0004$) indicating that in pun contexts literal meanings show effects of integration. In central lateral regions, after idiomatic contexts literal meanings showed integration effects as their amplitude for the P600 component was less positive than the unrelated baseline ($p<0.05$) whereas idiomatic meanings were treated as the unrelated baseline ($p=0.998$). After double-meaning consistent contexts, however, neither literal nor idiomatic meanings showed integration as both of them were treated as the unrelated baseline ($p=0.992$ and $p=0.359$ respectively). Again, the literal meanings showed less positive P600 effects than the idiomatic meanings ($p<0.044$).

In posterior medial regions, after idiomatic contexts the literal meanings showed strong integration effects as their amplitude for the P600 component was significantly less positive than the unrelated baseline ($p<0.0002$) whereas the idiomatic meanings were processed similarly to the unrelated baseline ($p=0.11$). After double-meaning consistent contexts, however, neither the literal nor idiomatic meanings showed integration ($p=0.802$ and $p=0.46$ respectively). In addition, the literal meanings showed less positive P600 effects than the

idiomatic meanings (p<0.038) suggesting that the pun contexts facilitated the integration of the literal meanings. In posterior lateral regions, after idiomatic contexts neither the literal nor the idiomatic meanings were smoothly integrated in the sentence context relative to the unrelated meaning (p=0.977 and p=0.563 respectively). After double-meaning consistent contexts, again neither the literal nor the idiomatic meanings showed reduced P600 effects relative to the unrelated baseline (p=0.996 and p=0.072 respectively), while the literal meanings showed less positive P600 effects than the idiomatic meanings (p<0.009).

The activation observed in the Right Hemisphere showed very similar patterns to those observed in the Left Hemisphere for both types of context. In frontal medial and lateral regions, after idiomatic contexts neither the literal nor the idiomatic meanings showed integration as both meanings were treated as unrelated (p=0.933 and p=0.851; p=0.999 and p=0.993 respectively). Similarly, after double-meaning consistent contexts medially neither the literal nor the idiomatic meanings showed integration relative to the baseline (p=0.155 and p=0.999 respectively). However, the literal meanings showed less positive P600 effects than the idiomatic meanings (p<0.009) suggesting that the pun context facilitated the integration of the literal meanings. In lateral regions, only the literal meanings were smoothly integrated in the sentence context relative to the unrelated meaning (p<0.0001) whereas the idiomatic meanings showed similar amplitudes for the P600 as the unrelated target (p=0.984).

In central medial regions, there were no context effects: both after idiomatic contexts and double-meaning consistent contexts, neither the literal nor the idiomatic meanings showed integration relative to the baseline (p=0.147 and p=0.997; p=0.668 and p=0.949 respectively). Similarly in central lateral regions there were no context effects; in particular, both after idiomatic contexts and double-meaning consistent contexts only the literal meanings showed less positive amplitudes for the P600 component relative to the unrelated baseline (p<0.0002 and p<0.0006 respectively) indicating their smooth integration. The idiomatic meanings were treated as unrelated (p=0.919 and p=0.854 respectively).

In posterior medial regions, after idiomatic contexts neither the literal nor the idiomatic meanings showed P600 effects relative to the unrelated baseline (p=0.542 and p=0.746 respectively). On the other hand, after double-meaning consistent contexts the literal meanings showed less positive P600 than the unrelated baseline indicating smooth integration (p<0.001) whereas the idiomatic meanings had similar amplitudes to the unrelated meanings (p=0.993). In posterior lateral regions, after idiomatic contexts both the literal meaning and the idiomatic meaning were smoothly integrated in the sentence context relative to the

unrelated meaning (p<0.0002 and p<0.044 respectively). After double-meaning consistent contexts, neither the literal nor the idiomatic meanings showed P600 effects relative to the unrelated baseline (p=0.992 and p=0.817 respectively) (see Figures 26, 27 and 28 below).

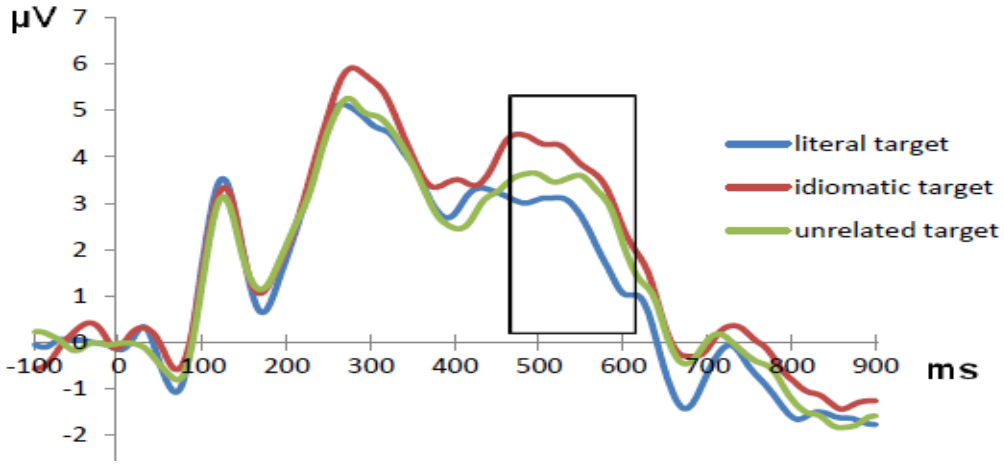

Figure 26 P600 effects (μV) for the literal and idiomatic meanings of non-decomposable idioms relative to the unrelated targets in single-meaning idiomatic contexts at P6 electrode site (chosen to reflect the posterior lateral locus of these effects).

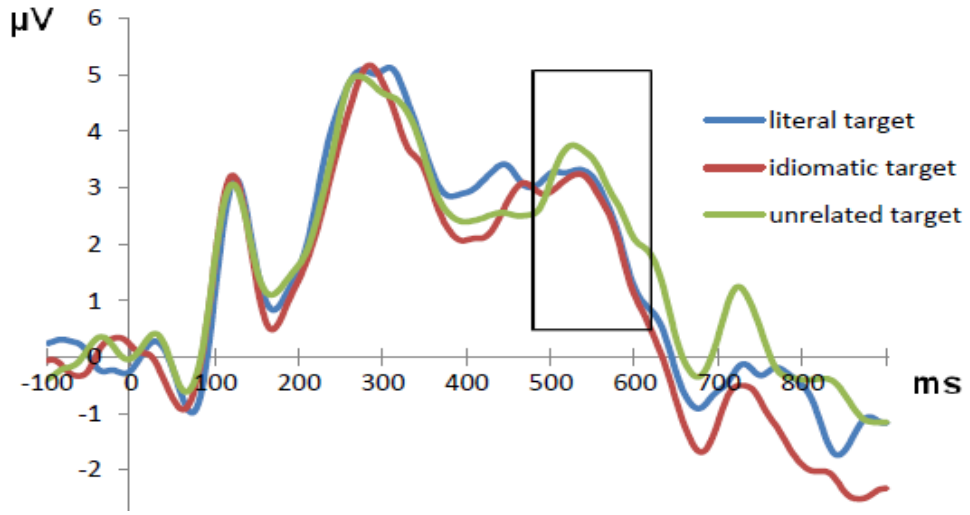

Figure 27 P600 effects (μV) for the literal and idiomatic meanings of non-decomposable idioms relative to the unrelated targets in double-meaning punning contexts at P6 electrode site (chosen to reflect the posterior lateral locus of these effects).

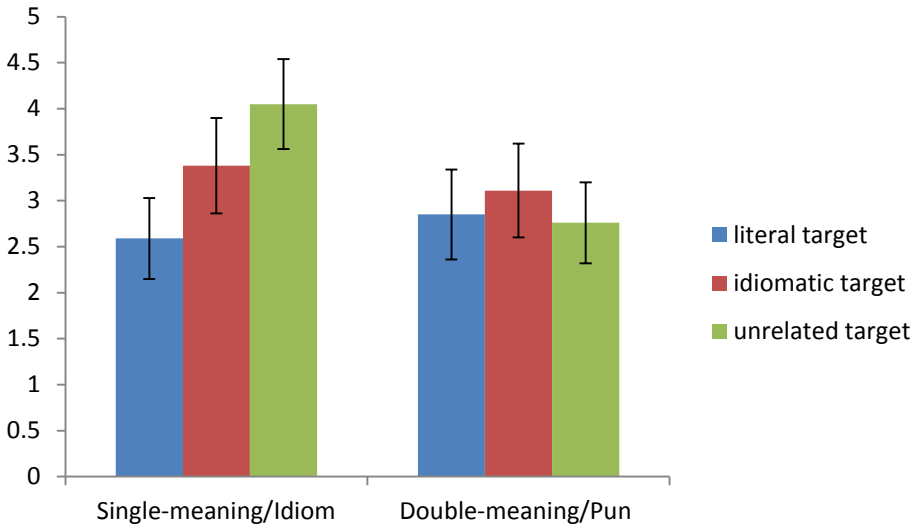

Figure 28 Bar graph depicting levels of integration for literal, idiomatic and unrelated targets in the posterior lateral region of the Right Hemisphere in single-meaning consistent and double-meaning consistent contexts. Context type is depicted on the x-axis.

ERP data: 470-620ms for decomposable idioms:

The data were subjected to a repeated measures ANOVA with five factors: Hemisphere (two levels: left, right), Location (three levels: frontal, central, posterior), Region (two levels: lateral, medial), Context (two levels: double-meaning consistent pun context, single-meaning consistent idiom context) and Target type (three levels: literally-related, idiomatically-related, unrelated). The analysis revealed a significant main effect of Target type [$F(2,48) = 6.969$, MS = 161.76, $p<0.003$, $\eta_p^2=0.225$]. Furthermore, there were significant two-way interactions of Location and Context [$F(2,48) = 3.618$, MS = 3.79, $p<0.043$, $\eta_p^2=0.131$], Hemisphere and Target type [$F(2,48) = 4.119$, MS = 2.54, $p<0.035$, $\eta_p^2=0.147$] as well as Region and Target type [$F(2,48) = 6.517$, MS = 2.13, $p<0.003$, $\eta_p^2 = 0.214$]. Additionally, there were three-way interactions of Location, Region and Context [$F(2,48) = 5.108$, MS = 2.72, $p<0.01$, $\eta_p^2=0.175$], Hemisphere, Location and Target type [$F(4,96) = 3.231$, MS = 0.90, $p<0.03$, $\eta_p^2 = 0.119$], Location, Context, Target type [$F(4,96) = 5.022$, MS = 3.11, $p<0.002$, $\eta_p^2=0.173$] as well as Region, Context and Target type [$F(2,48) = 5.256$, MS = 1.87, $p<0.011$, $\eta_p^2 = 0.179$]. Lastly, there were four-way interactions of Hemisphere, Location, Region and Context [$F(2,48) = 5.784$, MS = 3.69, $p<0.012$, $\eta_p^2=0.194$], Hemisphere, Location, Context and Target type [$F(4,96) = 3.753$, MS = 1.09, $p<0.009$, $\eta_p^2=0.135$], Hemisphere, Region, Context and Target type [$F(2,48)$

= 11.642, MS = 5.82, p<0.0001, η_p^2=0.327] as well as Location, Region, Context and Target type [F(4,96) = 4.189, MS = 1.31, p<0.009, η_p^2=0.149].

We focused on the significant four-way interaction of Hemisphere, Location, Context and Target type and conducted Newman-Keuls (p<0.05) post-hoc tests to explore it further. In the left hemisphere, in frontal locations after idiomatic contexts both literal and idiomatic meanings showed attenuated P600 effects relative to the unrelated baseline (p<0.0002 and p=0.005 respectively) indicating that both meanings of decomposable idioms were successfully integrated. However, after double-meaning consistent contexts, the literal targets were treated as the same as unrelated baseline targets (p=0.928) whereas the idiomatic meanings showed more pronounced P600 effects relative to the baseline (p<0.0002) indicating disruption to a smooth integration process.

In central locations, after idiomatic contexts the literal meanings displayed attenuated P600 effects relative to the baseline (p<0.0006) whereas the idiomatic meanings were treated as the same as the baseline unrelated meaning (p=0.159) indicating that only the literal meaning showed smooth integration effects. After double-meaning consistent contexts, the literal meanings still displayed attenuated P600 effects relative to the baseline (p<0.0006) whereas the idiomatic meanings showed more positive amplitudes relative to the baseline (p<0.0002).

In posterior locations, after idiomatic contexts, the literal meanings continued to show attenuated P600 effects relative to the unrelated baseline (p<0.0002) whereas the idiomatic meanings showed more positive amplitudes for the P600 component relative to the baseline (p<0.01) indicating that even in idiomatic contexts the idiomatic meanings of decomposable idioms show a pattern of processing costs during integration. After double-meaning consistent contexts, the literal meanings were processed similarly to the unrelated baseline (p=0.106) whereas the idiomatic meanings continued to exhibit more pronounced P600 effects relative to the baseline (p<0.0002) (see Figures 29 and 30).

As far as the patterns of activation in the right hemisphere are concerned, the double-meaning contexts revealed identical pattern to the one obtained in the left hemisphere, while the single-meaning contexts revealed a slightly different one from the one for the left hemisphere. In frontal locations after idiomatic contexts only literal meanings showed attenuated P600 effects relative to the unrelated baseline (p<0.009) while the idiomatic meanings were processed similarly to unrelated baseline targets (p=0.07). However, after double-meaning

consistent contexts, the literal targets did not differ from the unrelated baseline targets (p=0.825) whereas the idiomatic meanings showed more pronounced P600 effects relative to the baseline (p<0.0002) indicating disruption of the integration process.

In central locations, after idiomatic contexts the literal meanings did not show P600 effects relative to the baseline (p=0.5) whereas the idiomatic meanings showed more pronounced P600 effects relative to the baseline (p<0.0002) indicating again processing costs during integration. After double-meaning consistent contexts, the literal meanings displayed attenuated P600 effects relative to the baseline (p<0.0002) while the idiomatic meanings showed more positive amplitudes for the P600 component relative to the baseline (p<0.0002).

Finally, in posterior locations, after idiomatic contexts, the literal meanings continued to show attenuated P600 effects relative to the unrelated baseline (p<0.0001) whereas the idiomatic meanings were treated as similar to the unrelated meanings (p=0.954). After double-meaning consistent contexts, the literal meanings did not differ from the unrelated baseline (p=0.636) whereas the idiomatic meanings continued to exhibit more pronounced P600 effects relative to the baseline (p<0.0002).

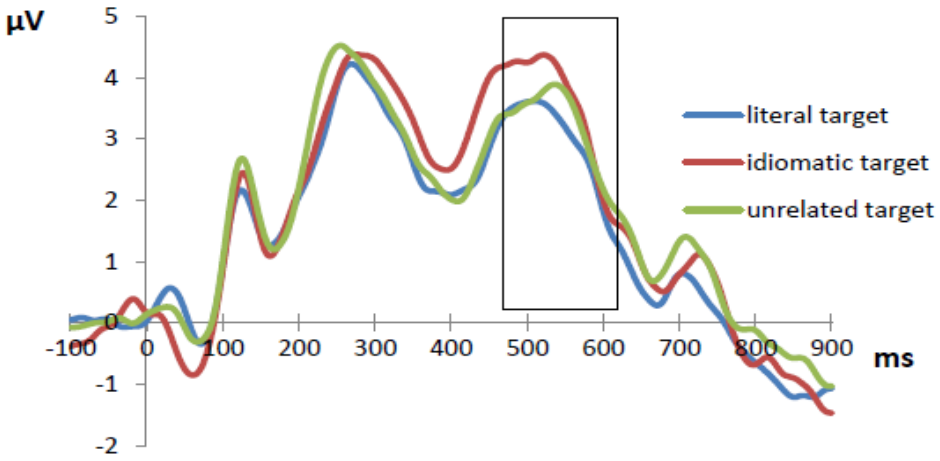

Figure 29 P600 (µV) effects for the literal and idiomatic meanings of decomposable idioms relative to the unrelated targets in single-meaning idiomatic contexts at P3 electrode site.

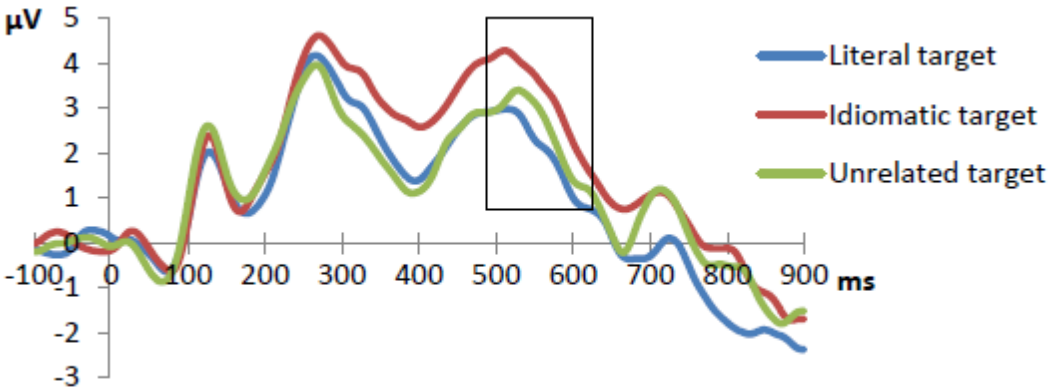

Figure 30 P600 effects (μV) for the literal and idiomatic meanings of decomposable idioms relative to the unrelated targets in double-meaning punning contexts at P3 electrode site.

6.2.5 Discussion – 470-620ms

Therefore, the pattern of meaning integration for the two types of idioms in the two types of contexts points to the following conclusions. Two important patterns of meaning integration have emerged for non-decomposable idioms used in single-meaning idiomatic and double-meaning punning contexts. Firstly, idiomatic contexts successfully integrated only the literal meanings at central lateral and posterior medial sites of the language-dominant left hemisphere, whereas the same contexts integrated both literal and idiomatic meanings at posterior lateral sites in the right hemisphere indicating that the dissimilar literal and idiomatic meanings of non-decomposable idioms show a right hemisphere advantage. Secondly, the double meaning consistent contexts motivated by non-decomposable idioms did not facilitate integration of both meanings simultaneously at any site. However, only the left hemisphere consistently facilitated integration to only the literal meanings at all sites across the scalp. In sum, even though, the right hemisphere showed a slight advantage in integrating the two meanings after single-meaning contexts, the left hemisphere showed a preference for the double-meaning punning contexts.

On the other hand, the pattern of meaning integration for decomposable idioms revealed a different picture. Firstly, after idiomatic contexts, idiomatic meanings were smoothly integrated only in frontal locations of the left hemisphere, whereas they showed more prominent P600 effects in posterior sites of the left hemisphere and in central locations of the right hemisphere. Secondly, after double-meaning consistent punning contexts, the idiomatic

meanings of decomposable idioms exhibited consistent interference effects as their P600 amplitudes were significantly more positive than those of the unrelated baseline across the scalp in both hemispheres. In sum, while the interference effects exhibited by the idiomatic meanings of decomposable idioms in single-meaning contexts are confined only to posterior lateral sites in the left hemisphere and central lateral sites in the right hemisphere, the same meanings after double-meaning consistent contexts incur interference effects at all sites across the scalp indicating the processing costs associated with this type of double meaning context. Overall, the data suggest that pun processing is more taxing for the syntactic combinatorial cognitive mechanism captured by the P600 component only in cases in which the two meanings that enter in the contrastive context of the pun are closely related, such as the literal and idiomatic meanings of decomposable idioms.

6.3 General discussion

The present study used event-related potentials (ERPs) to investigate the time-course of semantic activation and syntactic integration during pun processing focusing on the N400 and the P600 components of the brain signal. The experiment tested predictions derived from three different bottom-up models of non-literal language processing, namely the standard pragmatic approach (Grice, 1975), the graded salience hypothesis (Giora, 2012) and the direct access model (Gibbs, 1994). The overall pattern of the data is mostly consistent with non-modular approaches to non-literal language processing suggesting that pun comprehension is a highly interactive cognitive process in which the influence of context is exerted from the very early stages of processing. However, none of the leading models can accommodate fully the pattern of the data. We suggest that a top-down model of meaning construction such as conceptual blending (Coulson, 2001) is inherently more suited to explain the current data set as well as generate accurate predictions for future studies.

Puns and models of non-literal language processing

Overall, consistent with Coulson and Severens's (2007) findings, the N400 effects revealed that, relative to single-meaning contexts, the double-meaning consistent contexts facilitated access to multiple intended meanings for both non-decomposable and decomposable idioms. On the other hand, however, we obtained a different pattern for the P600 effects from that reported in Coulson and Severens (2007). The current data set for double-meaning consistent contexts in the P600 time-window was clearly dependent on idiom decomposition indicating that, relative to single-meaning contexts, integrating multiple intended meanings is more

taxing for puns in which the two meanings are semantically inter-related, i.e., the two intended meanings of decomposable idioms (decomposable puns). Thus, pun comprehension is an interactive process that takes into consideration both the fact that puns rely on two intended meanings as well as the particular semantic relationship between the two meanings that comprise the pun.

At first glance, the GSH (Giora, 2003) seems best equipped to account for pun processing as this hypothesis considers both the influence of context and lexical features such as meaning salience. However, the GSH predicts that during meaning access in punning contexts the literal and idiomatic meanings would compete for access in the same time-window leading to increased processing costs. In contrast to this assumption, such patterns of activation were observed only in single-meaning contexts for the semantically unrelated idiomatic and literal meanings of non-decomposable idioms. In punning contexts, contrary to that prediction, both for non-decomposable and decomposable idioms we obtained a pattern of meaning access opposite to the one predicted. In particular, in punning contexts for both types of idioms we observed a reduction of the N400 amplitude for both intended meanings indicating that the pun context facilitated access to both meanings relative to the idiomatic single-meaning consistent contexts. Even if the scope of the hypothesis is expanded to assume that in the case of punning contexts the expected meaning competition does not occur because the punning context is strong enough to resolve competition effects, which will explain the strong priming effects for the two meanings during meaning access, the Graded Salience Hypothesis would struggle to explain at least two further aspects of the present data. On the one hand, the GSH predicts that lexical features such as salience and degree of idiom decomposition affect semantic access, which would be observed in the N400 time-window. From the present data set it became clear that idiom decomposition was evident in that time-window but not for double-meaning consistent punning contexts. To be more specific, consistent with the Decomposition Hypothesis (Gibbs et al., 1989a) in single meaning idiomatic contexts, there were competition effects between the idiomatic meanings of non-decomposable idioms and their dissimilar literal meanings; such competition effects were not observed for the idiomatic meanings of decomposable idioms and their semantically related literal meanings. In sum, idiom decomposition affects idiom processing only in single meaning idiomatic contexts. When decomposable and non-decomposable idioms are used to create puns, decomposition effects are neutralised and the double-meaning consistent contexts guided access to the two intended meanings successfully and cost-free. Furthermore, according to the GSH, idiom decomposition is expected to affect meaning access only, thus predicting general overall

difficulties for double-meaning consistent contexts during syntactic integration captured by the P600 component irrespective of idiom decomposition. However, the data showed that there were clear decomposition effects in double-meaning consistent contexts indicating that only decomposable double-meaning consistent contexts incurred greater processing costs relative to a baseline. Thus, it becomes clear that while the GSH can account for the initial processing of idioms in single meaning consistent contexts, the results we obtained for the puns are inconsistent with predictions derived from the GSH.

The present data pose even more difficulties for the standard pragmatic approach (Grice, 1975). As a non-modular view of non-literal language processing it predicts that literal meanings are accessed first, recognised as deviant and inappropriate and a search for non-literal interpretations is thus initiated. Therefore, this approach predicts processing costs for puns both during meaning access and syntactic integration, which is not the case for the data in the current study. The evidence obtained from the N400 time-window clearly shows that punning contexts facilitate the semantic memory-based processing mechanism. Furthermore, the standard pragmatic approach does not take into consideration the underlying linguistic nature of non-literal language, which makes this model even less flexible and more inconsistent with the current data set. For example, although the standard pragmatic approach predicts general processing costs for puns during the P600 time-window, it does not predict the observed differences in processing costs between decomposable and non-decomposable idioms. Thus, the standard pragmatic approach cannot account for the complexity of the data set obtained in the current study.

Lastly, although the overall pattern of the present data is consistent with models of non-literal language processing that predict that contextual information affects processing from the very early stages of language comprehension, the results are not in accord with the direct access model (Gibbs, 1994). According to this model, non-literal language is accessed directly and independently from literal language without incurring extra cognitive effort. Additionally, the model claims that non-literal language is processed in a similar way to processing literal language thus not predicting differences in either the N400 or P600 time-window between double-meaning consistent and single-meaning consistent contexts. The results from the current experiment suggest that pun comprehension is easier than literal language processing in the earlier time window that captures processing of the semantic memory-based mechanism, while it is harder than literal language processing in the later time-window that captures processing of the syntactic combinatorial mechanism. Even if one argued that our

control condition comprised of idiomatic sentences, and idioms are often considered non-literal language in the first place thus not a strict literal control condition, the results still remain unequivocal as the double-meaning consistent context is consistently processed differently from the single meaning consistent context in both time-windows, lending, thus, limited support to the direct access model.

The present findings corroborate the findings of the lexical ambiguity study with central presentation discussed in Chapter 3 (see section 3.4). In particular, in that chapter we were confronted with a similar situation in which none of the above-mentioned leading models on non-literal language processing could accommodate the patterns of the data obtained from double meaning consistent contexts motivated by polysemous and homonymous ambiguous words. In Chapter 3 we argued that the principal most important shortcoming of each of these models is their underlying assumption that non-literal language has *one* intended meaning, which presents a digression from what is considered literal language. However, even though such an assumption might be consistent with other examples of non-literal language such as metaphors, ironies and sarcasm, in the case of puns we are faced with a different type of non-literal language, namely utterances that have at least *two* relevant and intended meanings being conveyed simultaneously. Therefore, it seems that the double meaning consistent nature of puns requires a model of meaning construction that is broad enough to account for the simultaneous multiplicity of all intended meanings that motivate it. In Chapter 3 we further suggested that the top-down model of conceptual blending is inherently better suited to explain the processing of puns as this model can account for the two important assumptions above as well as for the claim that meaning construction is explained by the combination of contextual effects and linguistic information (Coulson, 2001). In the current chapter it is further argued that the model of conceptual blending can account successfully for puns that are motivated by non-decomposable and decomposable idioms as well. While in Chapter 3 it was only suggested that conceptual blending as a model has the theoretical potential to accommodate representational differences between polysemous and homonymous ambiguous words, the pattern of data obtained in the current study allows us to explain in more detail how the model accounts for representational differences between decomposable and non-decomposable idioms as well.

Blending and non-decomposable idioms

According to the conceptual blending model of meaning construction, a frame is a conceptual organisation of knowledge that can be accessed directly by linguistic utterances (Coulson, 2001). The integration of two or more such frames gives rise to a new conceptual organisation, which is referred to as a blended space, or a hybrid frame. In particular, a hybrid frame (or a blend) minimally requires four elements for its existence, namely a common generic space, two distinct inputs that correspond to two different frames derived from the common generic space, and their joint projection to a new hybrid space, which is the blend (Fauconnier and Turner, 1998).

Applied to the puns used in the current study, it is argued that a non-decomposable idiom represents a common generic space that has the potential of producing at least two different inputs. According to the hybrid representation model for idioms (Cutting and Bock, 1997), the mental representations of idioms are conceptual wholes but are activated via an obligatory access to the literal meanings of their component words. For example, the meaning of *die* for the idiom *to bite the dust* is accessed directly but the literal meanings of *bite* and *dust* also receive activation. Additionally, the lack of a close semantic relation between the literal and idiomatic meanings of non-decomposable idioms justifies the lexicalised status of their idiomatic meanings. Therefore, one of the inputs the common generic space produces is an utterance in which the idiomatic expression is only understood literally in a compositional manner, i.e., as the sum total of the literal meanings of the idioms' component words. The second input produces a different utterance in which the same idiomatic expression is understood in a holistic manner, i.e., with its overall idiomatic meaning (see Figure 31 below).

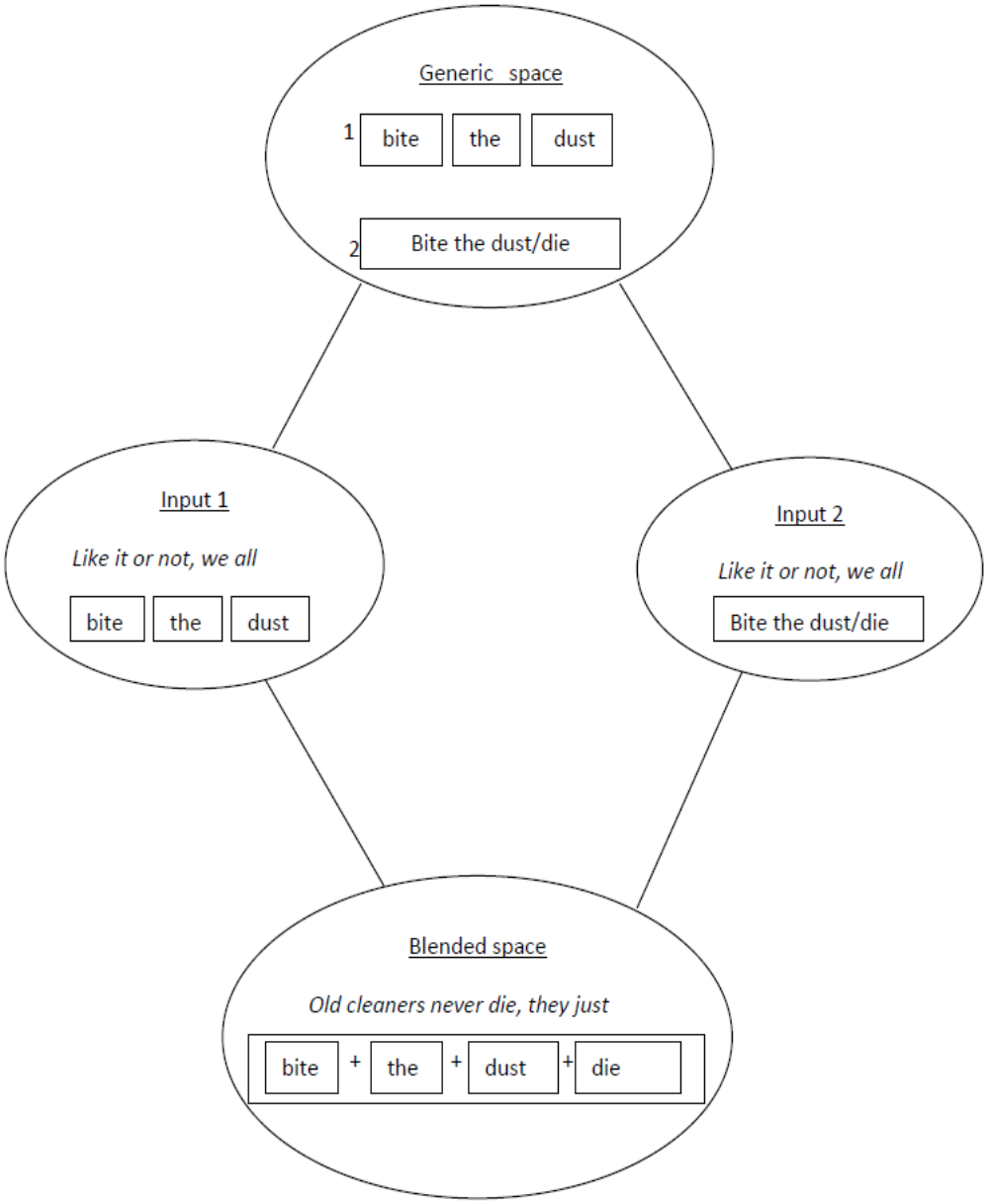

Figure 31 Graphic representation for processing puns motivated by non-decomposable idioms based on the four-space model diagram adapted from Fauconnier and Turner (1998).

Under the assumption that the time-window captured by the N400 component reflects the semantic memory-based mechanism whose operations are required for the access and activation of the linguistic potential of the common cognitive space, we argue that the N400 effects for the literal and idiomatic meanings of non-decomposable idioms in double-meaning consistent contexts suggest that puns do not require more cognitive resources to access two meanings simultaneously. In particular, after double-meaning consistent punning contexts, the

semantic competition observed in single-meaning contexts between the literal and idiomatic meanings of non-decomposable idioms was resolved and replaced by strong priming effects for both meanings. For example, consistent with the predictions of the Decomposition Hypothesis (Gibbs et al., 1989a), the dissimilarity between the literal meaning of the non-decomposable idiom *to bite the dust* and its overall idiomatic meaning caused them to compete with each other for access in single-meaning contexts leading to a delay in the activation of the idiomatic meanings caused by the interference from the literal meanings. On the other hand, when the non-decomposable idiom *to bite the dust* was used in punning contexts, the amplitudes for the N400 component for both literal and idiomatic meanings showed comparable reductions relative to the baseline indicating that the double-meaning consistent contexts not only resolved the meaning competition observed in single-meaning contexts but also facilitated access to both literal and idiomatic meaning to the same degree. Therefore, the data present a very strong case for the interactive nature of pun processing consistent with the blending model of meaning construction that argues that contextual effects are observable from the very early stages of meaning construction.

Once the generic space has been accessed and the two different inputs have been established, the resulting frames become joined in the double-meaning consistent punning context, i.e., the hybrid frame, or the blend. The blend is a novel utterance in which the meanings derived from the two input sentences converge once again but are now both maintained as relevant and intended at the same time. Thus, the blend, as exemplified by the punning context here, is characterised by the feature of compression of meaning that is seen as central for conceptual blending (e.g., Fauconnier, 2005). If the time-window captured by the P600 component reflects the cognitive processes required for the integration of semantic and syntactic features into an overall coherent communicative act (e.g., Kuperberg, 2007), we further argue that the P600 effects for the literal and idiomatic meanings of non-decomposable idioms suggest that double-meaning consistent contexts do not require more cognitive resources in the integration stage. In particular, after single meaning idiomatic contexts, both literal and idiomatic meanings exhibited attenuated P600 effects relative to the baseline (mainly evident in posterior lateral sites in the right hemisphere). These effects suggest that both meanings of non-decomposable idioms are engaged in the processes reflected in the combinatorial mechanism. However, after double-meaning consistent contexts only the literal meanings showed reduced amplitudes for the P600 component implying their smooth integration. The idiomatic meanings, which did not show any interference effects, were treated as unrelated. By definition the punning contexts bring to the foreground the literal re-interpretations of

idioms, which can explain why only these meanings showed integration effects while the idiomatic meanings were treated as unrelated in the punning contexts. It is possible that processing puns motivated by non-decomposable idioms is a semantic operation relying on a more shallow type of processing engaging the activation of semantically different lexicalised forms in the mental lexicon (as opposed to a deeper type of processing engaging a more conceptual level of disambiguating semantically similar meanings that would lead to engaging processes reflected in more syntactic and combinatorial operations) (Ferreira, 2007).

Blending and decomposable idioms

The conceptual blending model can explain the pattern of results obtained for decomposable puns too. When the double-meaning consistent contexts were motivated by decomposable idioms, we observed different patterns of N400 and P600 effects for the literal and idiomatic meanings of these idioms compared to the effects for non-decomposable idioms. However, we argue that the blending model can successfully explain the processing of decomposable idioms in punning contexts as well as account for the representational status of decomposable idioms in semantic space. To be more specific, decomposable idioms too represent a common generic space that has the potential of producing at least two different inputs. In this case, however, the close similarity between the literal and idiomatic meanings of decomposable idioms suggests that the idiomatic meanings of these idioms are not lexicalised but are likely to be derived on the basis of meaning extension from the literal meanings (Caillies and Butcher, 2007; Titone and Connine, 1999). Even though decomposable idioms are represented differently from non-decomposable idioms, the two inputs that the common generic space yields are similar, namely one that produces an utterance in which the idiomatic expression is only understood literally in a compositional manner and a second one that produces a different construction in which the idiomatic meaning is understood holistically (see Figure 32 below).

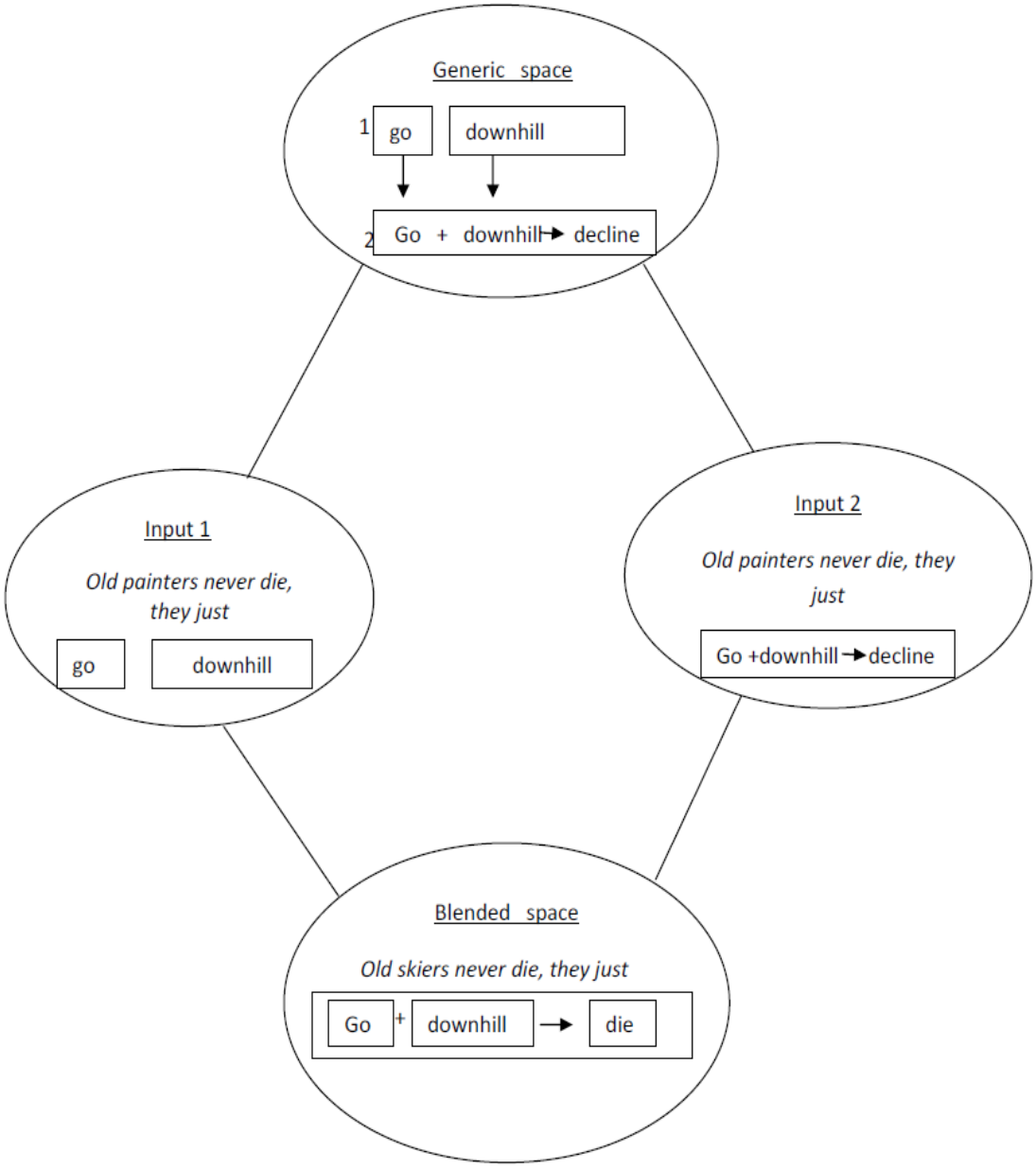

Figure 32 Graphic representation for processing puns motivated by decomposable idioms based on the four-space model diagram adapted from Fauconnier and Turner (1998).

Under the assumption that the time-window captured by the N400 component reflects the semantic memory-based mechanism whose operations are required for the access and activation of the linguistic potential of the common cognitive space, we argue that the N400 effects for the literal and idiomatic meanings of decomposable idioms in double-meaning consistent contexts provide strong evidence that puns do not require more cognitive resources in the very early stages of processing (similar to puns motivated by non-decomposable idioms).

In particular, consistent with the predictions of the Decomposition Hypothesis (Gibbs et al., 1989a), in single-meaning consistent contexts the close semantic relationship between the literal and idiomatic meanings of decomposable idioms facilitated the access to the idiomatic meanings. For example, the assumption is that the literal meanings of the component words of the decomposable idiom *to go downhill* contributed in an obvious way to the overall idiomatic meaning of *decline,* which resulted in the fast access to the idiomatic meaning while the literal meanings were treated as unrelated. After double-meaning consistent contexts, the semantic similarities between the literal and idiomatic meanings were further highlighted as the idiomatic meanings showed even stronger priming effects relative to those observed in single-meaning contexts while the literal meanings were also primed (unlike the literal meanings after idiomatic contexts). Therefore, the results from the N400 time-window again present a very strong case for the interactive nature of pun processing and are consistent with the predictions of the conceptual blending model arguing for the strong influence of context from the very early stages of language processing.

Once the generic space has been accessed and the two different inputs have been established, the two input frames become joined in the double-meaning consistent punning context, i.e., the hybrid frame, or the blend. However, unlike the results for non-decomposable idioms, the data for decomposable idioms suggest that double meaning consistent contexts required additional cognitive resources for the syntactic combinatorial mechanism. To be more specific, in single-meaning contexts a varied pattern for the two meanings of decomposable idioms emerged. The attenuated P600 effects for the literal meanings of decomposable idioms were spread out evenly across the scalp in both hemispheres suggesting the strong presence of the literal meanings and the wide neural network required for their processing. On the other hand, relative to the unrelated baseline, the idiomatic meanings of decomposable idioms showed more pronounced P600 effects at posterior sites in the left hemisphere and central sites in the right hemisphere, but attenuated P600 effects at frontal sites in the left hemisphere. The fact that the idiomatic meanings showed smooth integration effects at frontal sites but disrupted integration at posterior sites in the left hemisphere has implications for the mental representations of decomposable idioms. According to Caillies and Butcher (2007) the idiomatic meanings are not lexicalised in the mental lexicon but they are derived from the literal meanings of these idioms on the basis of meaning extension rules. This claim receives support from our data since frontal areas are usually implicated in rule-based inferential processes, which is consistent with the attenuated P600 effects for the idiomatic meanings at those sites. Moreover, the lack of lexicalised idiomatic meanings for decomposable idioms is

consistent with the disrupted integration effects at posterior sites, which are often implicated in the access and retrieval of pre-stored representations from long-term memory (for differences in semantic processing organised along an anterior-posterior axis see for example Traxler, 2012 and Friederici, 2011). After double-meaning consistent contexts, however, the idiomatic meanings showed more pronounced P600 amplitudes at all sites in both hemispheres implying that more cognitive effort was needed for integrating the idiomatic meanings in the pun condition. The fact that the idiomatic meanings showed processing only in specific regions after single-meaning idiomatic contexts, and the wide-spread processing costs for the same meanings in double-meaning consistent contexts leads to the interpretation that the additional effort required for the idiomatic meanings was incurred by the very close similarity between literal and idiomatic meanings of decomposable idioms that were forced to enter into the contrastive contexts of puns. In particular, the very close similarity between literal and idiomatic meanings for decomposable idioms makes the integration of the idiomatic ones harder in single meaning consistent contexts because the idiomatic meanings need to be derived on-line first. The double meaning contexts of puns highlight that difficulty even further, because once the idiomatic meaning has been derived from the literal meaning on the basis of semantic similarity, they have to be perceived as different from each other for the pun to work. Thus, we argue that appreciating the dual nature of punning contexts motivated by decomposable idioms happens relatively late, as a deeper more conceptual type of processing is required to perceive the contrastive nature of the pun. It is possible that processing puns motivated by decomposable idioms reflects a more syntactic and combinatorial type of processing as opposed to the more semantic processing required for puns based on non-decomposable idioms.

Implications for the nature of mental representations and right hemisphere involvement

The overall pattern of processing non-decomposable and decomposable puns as discussed so far has implications for two further topics discussed in this thesis, namely (i) the processing and representational similarities between non-decomposable idioms and homonymous words on the one hand, and on the other, between decomposable idioms and polysemous words, as well as (ii) the involvement of the right hemisphere in pun processing. In all experiments so far we found that holding two semantically related meanings in a contrastive punning context is a cognitively more taxing process than holding two semantically unrelated meanings in similarly contrastive contexts. We observed this effect for decomposable puns in the current chapter as well as for polysemous puns in Chapter 3**.** In particular, in Chapter 3, we presented data from a

behavioural study with central presentation of targets that aimed to investigate the processing costs associated with puns motivated by the semantically related senses of polysemous words, and puns motivated by the semantically dissimilar meanings of homonymous words. The results from Experiment 3 that aimed to tap onto automatic pun processing suggested that puns triggered by polysemous words were more taxing compared to an unrelated baseline; additionally, these puns were more taxing than processing puns based on homonymous words. Based on these findings and the findings of the present study, we conclude that decomposable puns and polysemous puns show similar processing patterns, while non-decomposable puns and homonymous puns share processing patterns as well. We claim that the analogous processing patterns are driven by the semantic similarities between literal and idiomatic meanings for decomposable idioms and those between the dominant and subordinate senses of polysemous words on the one hand, and the semantic dissimilarities between the literal and idiomatic meanings of non-decomposable idioms and between the dominant and subordinate meanings of homonymous words. These findings, thus, delineate an important aspect that affects pun processing, namely the degree of the semantic similarity between the two intended meanings.

The results of the present study also have important implications about the involvement of the two cerebral hemispheres in pun processing. Chapter 4 presented behavioural data from a half-field semantic priming study that aimed to investigate hemispheric differences for processing puns triggered by non-decomposable idioms and puns triggered by decomposable idioms. The results from that study revealed that non-decomposable puns were processed exclusively in the left hemisphere, whereas puns motivated by decomposable idioms were processed equally well in the two hemispheres implying some right hemisphere involvement in the processing of decomposable idioms. Even though the EEG methodology does not have the precise spatial resolution of other neuroimaging techniques (e.g., MEG or fMRI), the differences in the scalp distributions of the N400 and P600 effects for non-decomposable and decomposable puns become important here especially because they mirror the earlier results from the behavioural half-field study that used the same materials (see Chapter 4). To be more specific, the literal and idiomatic meanings of non-decomposable idioms in double-meaning consistent contexts exclusively engaged a *left-lateralised* network of neural generators both during the N400 and P600 components. However, the literal and idiomatic meanings of decomposable idioms in double-meaning consistent contexts engaged symmetrically both a *left-lateralised* and a *right-lateralised* network of generators. In other words, processing decomposable puns engaged the two hemispheres. Since, according to Vigneau et al. (2011),

right hemisphere resources are recruited in cases that require more processing costs, we link the bilateral pattern of processing decomposable puns with the more taxing processing of the idiomatic meanings of decomposable idioms. Thus, both the behavioural and EEG data sets reveal the same trend of hemispheric asymmetries for non-decomposable and decomposable puns. In sum, we conclude that the electrophysiological data allow us to argue more convincingly that the right hemisphere is indeed involved in the processing of some puns, namely decomposable puns.

6.4 Conclusion

Crucially, the experiment found further support for our earlier claim that the top-down conceptual blending model of meaning construction (Coulson, 2001) is perhaps best suited to explain pun processing as observed in the present thesis. Based on the data set presented in this chapter together with all the results presented so far in this thesis it becomes evident that any investigation on pun processing needs to take into consideration the inherent linguistic nature of the language that motivates the pun. Our findings indicate that it is not accurate to suggest that pun comprehension overall is a cognitively taxing process; instead, it is more accurate to suggest that processing puns motivated by two similar meanings is more cognitively taxing relative to processing puns motivated by two dissimilar meanings (as exemplified by the processing costs incurred for puns motivated by decomposable idioms or polysemous words). In addition, differential processing costs for decomposable and non-decomposable puns translate to hemispheric asymmetries for these two types of puns. In particular, consistent with the results from the behavioural half-field study discussed in Chapter 4, decomposable puns exhibited bilateral recruitment whereas non-decomposable idioms employed strictly left hemisphere neural networks, indicating that the right hemisphere contributes to the comprehension of puns when processing requirements are increased.

Chapter 7. General Discussion

The findings presented in this thesis provide important insights into non-literal language processing, and pun comprehension in particular. They also make an important theoretical contribution to the understanding of other areas of non-literal language research such as idiom processing and lexical ambiguity resolution. The thesis addressed the issue of the internal semantic structure of puns by investigating the processing costs and hemispheric asymmetries associated with processing differences in the language motivating the dual meaning in puns. In particular, we focused on puns that were either motivated by the inherent ambiguity of idioms or of words with multiple meanings. The studies employed both behavioural and electrophysiological measurements to provide answers to the above questions. Chapters 2 and 3 used central presentation to investigate puns motivated by idioms and ambiguous words respectively, while Chapters 4 and 5 used the divided visual field methodology to investigate hemispheric effects with the same materials. Finally, Chapter 6 investigated the neural correlates of pun processing motivated by idioms using EEG/ERPs. The overall pattern of results suggests that the internal structure of puns significantly affects the time-course of dual meaning activation. Moreover, the results indicate that the more semantically similar and plausible the two meanings are the harder the processing becomes leading to greater RH activation. Thus, the results are consistent with our initial hypothesis that previous research on pun processing failed to report RH involvement as it did not consider the internal structure of puns.

7.1 Time-course of double meaning activation – inter-hemispheric pun processing

The first key question we addressed at the start of this thesis was the time-course of double meaning activation for pun processing as well as the role of the internal pun semantics. The main findings of our studies lead to the conclusion that under conditions of automatic processing the time-course of double meaning activation is affected significantly by the semantic similarity between the two meanings residing in the pun. More specifically the data suggest that if the two meanings are closely related semantically then pun comprehension will reveal processing costs. This finding is supported both by the behavioural and the electrophysiological data. Experiment 3 revealed that puns motivated by the two semantically related senses of polysemous ambiguous words incurred greater processing costs relative to single-meaning baseline contexts. Additionally, the electrophysiological data from Experiment 9 also demonstrated that puns motivated by the semantically related literal and idiomatic

meanings of decomposable idioms incurred greater processing costs relative to single-meaning baseline contexts. Conversely, the same experiments revealed lack of processing costs for puns motivated by the semantically dissimilar meanings of homonyms (Experiment 3) and the semantically unrelated literal and idiomatic meanings of non-decomposable idioms (Experiment 9). Thus, we conclude that during automatic pun processing the increased similarity between the two meanings of the pun leads to increased processing costs. The results from Experiments 2 and 4, which investigated the later processing stages of puns motivated by idioms and ambiguous words respectively, were less consistent. Neither of the two experiments revealed that the degree of similarity between the two meanings of the pun affects processing. Similarly, neither of the experiments revealed processing costs. On the contrary, Experiment 2 showed that puns triggered by idioms were processed faster than single-meaning baseline sentences, indicating that processing costs for puns are encountered primarily during the early automatic stages of processing. Further research in this area should ascertain whether the similarity of the two meanings of puns leads to processing costs only under conditions of automatic processing or whether it can also be observed during controlled processing with specific experimental manipulations (for example, when processing is more taxing possibly with a dual task).

Even though the finding that the similarities between the two meanings of the pun translate to greater cognitive demands is our overarching conclusion concerning both puns motivated by idioms and puns motivated by ambiguous words, we do not wish to argue that these two types of puns are processed in the same way. As discussed in Section 3.6, the time-course of double meaning activation for puns motivated by idiomatic expressions differs from the time-course of double-meaning activation for puns motivated by ambiguous words. Firstly, when puns are based on idiomatic expressions, the pun effect becomes evident during the later stages of language processing (Experiment 2: ISI: 750ms). Conversely, when puns are based on ambiguous words, the pun effect becomes evident during the early stages of language processing (Experiment 3: ISI: 0ms). We argued in Section 3.6 that since the pun relies on the activation and maintenance of two meanings, the difference between puns-idioms and puns-ambiguous words was due to the possible slower rise of some idiomatic meanings, whereas all meanings of ambiguous words seem to be accessed exhaustively from the very early stages of language processing. Secondly, puns based on idiomatic expressions were processed faster relative to single-meaning baseline contexts, whereas this was not the case for puns based on ambiguous words, which were either processed similarly to single-meaning baselines (homonymous puns), or were processed slower than single-meaning baseline control contexts

(polysemous puns). Nevertheless, even though puns-idioms and puns-ambiguous words are processed at different speeds and require differing amount of cognitive effort, the overall factor which could predict processing costs is the semantic similarity between the two meanings of the pun.

7.2 Hemispheric asymmetries for pun processing

The second aim of this thesis was to investigate to what extent the right hemisphere is involved in pun processing. We hypothesised that previous research in this area failed to report that the right hemisphere contributed significantly during the comprehension of puns because none of the studies (e.g., Coulson and Severens, 2007; Kana and Wadsworth, 2012) considered the internal semantic structure triggering the duality of meaning. Consistent with our hypothesis, the behavioural data from the two half-field studies as well as the neural data suggest that the right hemisphere is involved in the processing of some puns. In particular, Experiments 5 and 6, which investigated the hemispheric asymmetries of non-decomposable and decomposable puns, revealed that while non-decomposable puns were exclusively processed in the language dominant left hemisphere, decomposable puns recruited processing resources from the right hemisphere too. This effect was observed both during early and late processing. The EEG/ERP data from Experiment 9 provided further support for these findings at a neural level. Furthermore, Experiment 8, which investigated the hemispheric asymmetries of puns motivated by ambiguous words, showed that during the later stages of processing these puns were processed faster by the right hemisphere irrespective of sense-relatedness effects. Overall, these findings are mostly consistent with the cognitive continuum hypothesis that suggests that differential hemispheric processing for non-literal language is predicted on the basis of the linguistic nature motivating the non-literal language (Faust and Kenett, 2014). More specifically, our results for pun processing occupy the three cardinal points of the continuum described by Faust and Kenett (2014). In particular, LH preference was exhibited for processing non-decomposable puns, RH preference was displayed for processing puns triggered by ambiguous words, and finally occupying the middle point of the continuum decomposable puns were processed equally well by the two hemispheres. Given the evidence that the right hemisphere is involved in the processing of more difficult language (e.g., Vigneau et al., 2011) as well as our finding that the degree of similarity between the two meanings of puns can lead to processing costs, we argue that the pattern of hemispheric asymmetries in the present data is caused by varying amounts of processing costs for the three types of puns. Therefore, we argue that right hemisphere involvement will be induced by puns that are

motivated by two (or more) meanings that are similar to each other and are formulating two (or more) plausible utterances.

7.3 Implications for models of non-literal language processing

The studies presented in this thesis have implications for the explanatory potential of the leading compositional models of non-literal language processing, namely the standard pragmatic approach (Grice, 1975), the direct access model (Gibbs, 1994) and the graded salience hypothesis (Giora, 2012). As we discussed in Section 3.6, the studies in this thesis did not support the predictions derived from any of these models. Firstly, both the standard pragmatic approach and the graded salience hypothesis predict that pun processing is more cognitively taxing than non-literal language processing during early and late stages of processing alike. However, our data revealed that only polysemous puns (see Experiment 3) and decomposable puns (see Experiment 9) required additional processing effort under conditions of automatic processing. Secondly, the direct access model does not predict any differences between pun processing and the related single-meaning consistent language either during the early or the later stages of processing. Yet, all our data revealed pun-related effects apart from the central presentation study with homonymous puns (Experiments 3 and 4) for which there were no processing differences between double-meaning consistent contexts (i.e., puns motivated by homonyms) and related single-meaning consistent contexts either in the early of the later processing stages. 'Thirdly, none of these three models predicts that processing puns will be less taxing relative to baseline single-meaning contexts. However, Experiment 2 revealed that puns that exploit the inherent ambiguity between the literal and idiomatic meanings of idioms were processed *faster* during a late processing stage. Thus, it is clear that while each of these three models can explain a small part of the data, none of them can account for the overall pattern of processing costs gleaned from the present findings.

A further shortcoming of both the standard pragmatic approach and the direct access model is that neither model makes any predictions about possible right hemisphere involvement in non-literal language processing. Predictions of hemispheric asymmetries must be an important aspect of any contemporary model of figurative language comprehension given the steadily growing evidence of right hemisphere involvement in that process (e.g., Giora, 2007; Vigneau et al., 2011). On the other hand, the graded salience hypothesis does predict RH involvement for less salient language. However, our data suggest that the RH involvement was induced by the similarity and plausibility of the two meanings in the pun rather than by salience. Thus, clearly none of the existing models on non-literal language processing can accommodate the

present findings that the RH is indeed involved in the processing of some puns, namely puns motivated by decomposable idioms and those motivated by ambiguous words.

The inability of each of these traditional models to explain non-literal language processing has already been implied in research on irony (Regel, et al., 2010). The complexity of more recent data sets including the ones we present in this thesis requires a model of meaning processing that is interactive in nature to be able to account for the very early effects of context but also flexible enough to consider the internal structure of puns and the possibility of language to intend more than one meaning at a time. We have already suggested elsewhere in this thesis (see Chapter 3, Sections 3.4 and 3.6 in particular as well as Chapter 6, Section 6.3) that the framework of the conceptual blending theory (Fauconnier and Turner, 1998) is one possible model that might be able to account for our results more successfully. Even though that theory has not been associated with data on puns yet, it has been applied to processing counterfactuals, which is another example of dual language (de Vega and Urrutia, 2011; de Vega, Urrutia and Riffo, 2007; Santamaria, Espino and Byrne, 2005) as well as processing metaphors (Coulson, 2001; Coulson and Van Petten, 2002). Additionally, it might be able to accommodate data on pun processing (e.g., Coulson and Severens, 2007; Sheridan et al., 2009) that is not easily accommodated by any of the three leading models on non-literal language processing. The rest of this section will focus on conceptual blending trying to explain why it seems a more suitable theory to account for pun comprehension and how its scope could be narrowed down to produce clearer and testable hypotheses in the future.

7.4 Conceptual blending and pun processing

According to the conceptual blending theory, meaning construction is a creative process that relies on the development of a novel conceptualization that has its own emergent structure. The principal attraction of that framework lies in the introduction of the theoretical construct of the *blend*. According to Fauconnier and Turner (1998), the blend is a product of a specific cognitive process that requires the accessing of a generic space which holds the potential to produce two different inputs only to be integrated again into a new hybrid mental space. Such integration leads to a new emerging structure that contains information from both inputs but it is at the same time essentially different from either one of them. The claim here is that double-meaning consistent sentences such as '*The prince with a bad tooth got a* ***crown****.'* and *'Old cleaners never die, they just* ***bite the dust****.'* are examples that involve blending. The emergent structure of the pun is represented in the fact that the pun is the only utterance that has the potential to be humorous, but at the same time it allows us to perceive the two

separate input utterances as well, which are based on the common generic space either of an ambiguous word or idiom. For example, the common generic space in the first example above is the mental space that holds all the senses of the polysemous word *crown.* A source of input 1 is a sentence such as '*When Elizabeth became a queen she got a crown.'* and a source of input 2 –'*The NHS charges three hundred pounds for a crown.'* However, the blend '*The prince with a bad tooth got a crown.'* inherits the meaning of a head ornament from input 1 and also that of tooth filling from input 2. Thus, the blend is linked to the two inputs in an obvious way but at the same time it has its own emerging structure that is different from either of the two inputs.

According to Fauconnier and Turner (1998), emergent structures are products of three blending processes, namely *composition, completion* and *elaboration* (for a similar view see Coulson and Oakley, 2000; and Coulson, 2001). In the conceptual blending literature, *composition* is the process that governs a cross-input matching procedure (such as for example a formal identity of *crown* used both in input 1 and input 2), whereas the process of *completion* relates to recruiting background knowledge from long-term memory that completes the composition of the blend (e.g., engaging pre-existing knowledge about jokes, humour, and phatic communication). Finally, *elaboration* (closely linked to the process of completion) involves either a mental or even physical simulation of the event contained in the blend. It could be argued that elaboration might be linked to activating embodied simulations of actions (e.g., Fauconnier and Turner, 1998).

Although conceptual blending has often been criticized for having a strong post-hoc explanatory and descriptive power but very little predictive strength (see Gibbs, 2000 for a general and detailed view of this position), attempts have been made to constrain the theory allowing us to further current understanding of how the brain integrates information in order to construct meaning. For example, Grady (2000) associated central cognitive operations that blending theory couched in conceptual terms such as *composition* and *completion* with the more fundamental cognitive operations of *binding* and *spreading activation*. In particular, Grady (2000) argues that *composition* could possibly be the product of binding, a process that relies on the unification of pre-activated distinct neural ensembles of neocortical regions. Grady (2000) argues further that *completion* is most likely the product of spreading activation.

We believe that the electrophysiological literature on language processing can provide a complementary temporal perspective on the cognitive processes behind *composition* and *completion*. Most neuro-cognitive models of language processing agree that processing

unfolds in time according to two main mechanisms (e.g., Kuperberg, 2007). Firstly, it is argued that a semantic memory-based operation is operative around 400ms after stimulus presentation indicating relative ease of activating pre-stored representations and mapping their semantic meaning onto new incoming stimuli. This operation is reflected in modulations in the N400 component of the continuous brain signal. So, if *composition* is the outcome of the semantic memory-based mechanism, this process must ensure that a generic space with pre-stored mental representations is accessed and further semantic mapping can proceed. Secondly, it is argued in the electrophysiological literature that a syntactic combinatorial mechanism is operative around 600ms post-stimulus presentation indicating the relative ease of combining pre-activated semantic information into one coherent and meaningful communicative act. This operation is reflected in the modulations of the P600 component of the continuous brain signal. If *completion* is the outcome of the syntactic/thematic combinatorial mechanism, this process must ensure that all possible meanings and utterances motivating the pun are established and co-exist in the blended space. Thus, the electrophysiological literature on language processing might be able to offer a more precise temporal course of processing double-meaning consistent language from a conceptual blending perspective.

To our knowledge, conceptual blending has not made any explicit links to potential hemispheric asymmetries in the process of meaning construction. However, we believe that two separate lines of research can inform conceptual blending theory to be able to formulate predictions for right hemisphere involvement for pun processing (and indeed non-literal language, more generally). Firstly, given the evidence that the right hemisphere is involved in the processing of more taxing linguistic (and non-linguistic) stimuli, as well as the evidence that the N400 and P600 components indicate relative ease in processing, we can assume that difficulties in processing indicated by these two components will correlate with right hemisphere involvement. Thus, using evidence of right hemisphere involvement and the two EEG components as indexes of ease/difficulty of processing, we may be able to predict more accurately whether the process of *composition* (the N400 component) or that of *completion* (the P600 component) causes the greater difficulty in creating the emergent structure of the blend. Secondly, given the evidence provided by the cognitive continuum hypothesis (Faust and Kenett, 2014) that the degree of right hemisphere involvement for non-literal language processing is affected by factors such as novelty, conventionality, and familiarity and the particular focus of conceptual blending theory on the meanings contained in the input sentences motivating the blend, we might be able to formulate predictions about which inputs

could potentially incur right hemisphere resources. A more serious consideration here is the fact that the EEG methodology does not have an accurate spatial resolution (unlike for example MEG, or fMRI), which will require employing different methodologies in order to confirm or disprove hypotheses derived on the basis of hemispheric asymmetries detected in scalp distributions for either N400 or P600 effects. However, from EEG data sets we might be able to glean information that is to be further explored by different methodologies. Overall, we suggest that by drawing on the electrophysiological literature as well as knowledge about the factors inducing right hemisphere involvement in processing non-literal language, conceptual blending theory might be narrowed down enough to offer testable hypotheses concerning both processing costs and hemispheric asymmetries.

The main findings reported in this thesis may provide further insights and could be considered as a step towards formulating testable hypotheses within the framework of conceptual blending theory. For example, our data suggest that during automatic processing, double-meaning consistent contexts facilitate the composition stage in the blend process (time-locked to the N400 component) whereas they cause disruption during the completion stage in the blend (the P600 component). Additionally, recall from the literature review in Chapter 1 that Coulson and Severens (2007) reported the same pattern of results, namely attenuated N400 effects for the two meanings of the puns, but also more pronounced P600 effects for the same meanings. Sheridan et al (2009) further revealed that in an eye-tracking experiment, relative to single-meaning contexts participants spent *less* reading time on an ambiguous homonym preceded by double-meaning punning contexts, but spent *longer* reading time in the disambiguating region following the ambiguous homograph. Collectively, the data in the present thesis as well as the two earlier studies (Coulson and Severens, 2007; Sheridan et al, 2009) point to the assumption that early stages of processing puns may be easier relative to single-meaning consistent contexts, whereas difficulties seem to arise in later stages of processing possibly due to the inability to integrate one meaning only. Our main findings further suggest that such inability may be highlighted by the similarity of the two meanings. Thus, we argue that puns are a figure of speech whose duality of meaning makes them easier to process in the early stage of processing, while the same duality turns into a processing disadvantage in the later stages of processing.

By carefully considering the internal structure of the pun, we argue that our data suggest that the disruption is most likely caused by the degree of semantic similarity between the two input sentences. Experiment 9 revealed that double-meaning consistent contexts motivated by the

semantically similar literal and idiomatic meanings of decomposable idioms were significantly harder to process in the P600 time-window, relative to double-meaning consistent contexts motivated by the semantically dissimilar literal and idiomatic meanings of non-decomposable idioms. The difficulties linked to the processing of the former double-meaning consistent contexts led to significantly greater right hemisphere involvement for their processing (relative to double meaning consistent contexts motivated by non-decomposable idioms that did not exhibit any right hemisphere involvement). This claim receives some support from our behavioural data too. In particular, results from the half-field priming study reported in Chapter 4 revealed an identical pattern of slower responses for decomposable puns relative to non-decomposable ones, which also led to right hemisphere involvement only for decomposable puns. Lastly, Chapter 3 demonstrated that processing polysemous puns was significantly slower than processing homonymous puns, thus highlighting the similarities between decomposable puns and polysemous puns but also showing that the semantic similarities between the two meanings of the pun caused the extra processing costs. We speculate that processing semantic similarities in a contrastive punning context incurs greater processing costs (relative to processing semantic dissimilarities) because they necessitate a deeper type of processing to disambiguate the full ambiguity of the pun. To use an everyday example to illustrate our point, we can imagine that in a context in which two yellow apples have to be perceived as different enough to be easily individuated (perhaps one is only slightly smaller than the other), we would probably have to concentrate harder to find the differences between them compared to a similar situation in which an apple and a banana have to be perceived as different enough to find the differences. Thus, if two similar objects required greater concentration to perceive some distinctive differences between them, we speculate that two similar meanings are likely to require deeper processing (which will be more taxing too) to hold them in a contrastive punning context. Overall, we claim that pun processing might be a two-step process that is facilitated by the duality of meanings during the first step, but a close semantic relationship between the two meanings might lead to processing difficulties during the second stage of processing. Within the framework of the conceptual blending theory, the facilitation will be evident by reduced N400 effects during the first processing step, but more positive P600 effects during the second processing step if the two meanings of the pun are semantically related and/or similar.

7.5 Future directions and further research

Further research in this area will be able to validate the current results, as well as expand them in at least three directions. Firstly, more electrophysiological studies are required to replicate the two-step processing model outlined above suggesting the overall facilitative effects of double meaning consistent contexts during the stage of composing a pun as well as the possible interference effects of the same contexts during the later stage of completing a pun if the two meanings are semantically closely related. Further research will be able to show whether the same pattern of two-stage processing is also evident for pun comprehension when later processing stages are targeted. Such a goal is easily achieved by carrying out an additional study using the same materials and procedure as in Experiment 9 but presenting the targets with a delay of 750ms after prime-offset. If the two-staged processing patterns observed during the early stages of pun processing holds during the later stages of processing too, then we would expect to see reduced N400 effects in the pun condition (relative to the single-meaning consistent baseline) and more pronounced P600 effects in the pun condition (relative to single-meaning consistent controls). Crucially, we would expect to see more pronounced P600 effects for double meaning consistent contexts in conditions that require the integration of two semantically similar meanings. Secondly, studies employing double meaning consistent contexts motivated by polysemous and homonymous words might be able to further the field by replicating the finding that indeed the similarity between the two meanings of puns incurs processing costs during the second stage of pun processing. In particular, studies using polysemous and homonymous puns will be able to tease apart the role of the similarity between the two meanings of the puns and the plausibility of each of the two input utterances that motivate the emergent structure of the blend (i.e., the pun). In other words, both homonymous and polysemous puns are double meaning consistent contexts for which the two utterances are plausible, but only for polysemous puns the meanings of the two senses of the ambiguous words are related semantically. In particular, the new hypothesis within the framework of conceptual blending would predict that double meaning consistent contexts motivated both by polysemous and homonymous words will lead to a reduction of the N400 amplitudes (relative to single-meaning consistent baselines), but more pronounced P600 effects only for double-meaning consistent contexts motivated by polysemous words. However, if the difficulty in the P600 time-window is augmented by the plausibility of each of the two meanings of the pun and is not caused only by the semantic similarities between the meanings, then we expect to see more pronounced P600 effects for double-meaning consistent contexts motivated by homonymous words as well. Lastly, the field will benefit from

investigating other forms of dual language such as counterfactuals, hypotheticals, metaphors, idioms as well as ironic statements. Using any one of these additional forms will be able to tease apart the role of intentional duality (i.e., puns) and unintentional duality (i.e., inherent linguistic ambiguities) and their associated costs in processing.

7.6 Contributions to other research areas

The results presented in this thesis are also beneficial for a number of other research areas. For example, the main findings from Chapter 2 can inform contemporary models of on-line idiom processing and revisit hypotheses of mental representations of idiomatic meanings. More specifically, the results can contribute to a line of research investigating context effects in idiom processing as well as to research exploring the main predictions derived from the Idiom Decomposition Hypothesis (Gibbs et al, 1989a). Even though the results are not fully consistent with the hypothesis, they provide strong experimental evidence supporting the psychological reality of idiom decomposition, which has been challenged by previous research (Tabossi et al., 2008, Titone and Connine, 1999). Furthermore, the results from Chapter 4 provided additional evidence in support of hemispheric asymmetries for idiom processing, and the role of idiom decomposition in that process. Thus they can inform research that aims to uncover hemispheric specificities for processing idioms.

Similarly, the main findings from Chapter 3 can inform contemporary models of lexical ambiguity resolution. They can specifically contribute to a line of research investigating context effects in lexical ambiguity resolution as well as any possible sense-relatedness effects in that process. Also, the results have implications for the representational differences between ambiguous words with multiple meanings (homonyms), and ambiguous words with multiple senses (polysemes). The main results from Chapter 5 provided further evidence in support of hemispheric differences during lexical ambiguity resolution, and the role of sense-relatedness in that process. To our knowledge, this study is the only one that explores hemispheric asymmetries for polysemous and homonymous words used in sentence contexts.

Finally, the main findings of Chapter 6 contribute to the electrophysiological literature on language processing concerning two different but interrelated aspects, namely the cognitive processes reflected in the N400 component and those reflected in the P600 component. Our results could be relevant for research that investigates the semantic-syntactic divide between the N400 and P600 effects. Additionally, the findings can also provide important insights into

on-line idiom processing using the EEG methodology, which provides a more precise measure of the time-course of meaning activation.

7.7 Conclusions

The results from the studies comprising this thesis offer strong support for the hypothesis that the internal semantics of puns plays an important role in the time-course of meaning activation during inter-hemispheric processing. Furthermore, the studies expand the DVF literature on pun processing by providing for the first time experimental support for right hemisphere involvement during pun processing. Thus, it becomes evident that the internal structure of puns is a factor that needs to be carefully considered in future studies. The results have important implications for related areas of research, but most importantly for contemporary models of non-literal language processing. We argued that the leading models, namely the standard pragmatic approach, the direct access model and the graded salience hypothesis, were not able to accommodate the present data set. Instead, we argued that the conceptual blending theory can accommodate the present findings and is potentially a more suitable theory to account for complex data sets. We suggested that by combining knowledge from the electrophysiological literature, together with knowledge from the literature exploring hemispheric asymmetries, the scope of the conceptual blending theory might be narrowed down enough so that it is able to produce clearer and testable hypotheses. Clearly further research is vital in this direction as the conceptual blending theory could be developed into another model to account for non-literal language processing in general.

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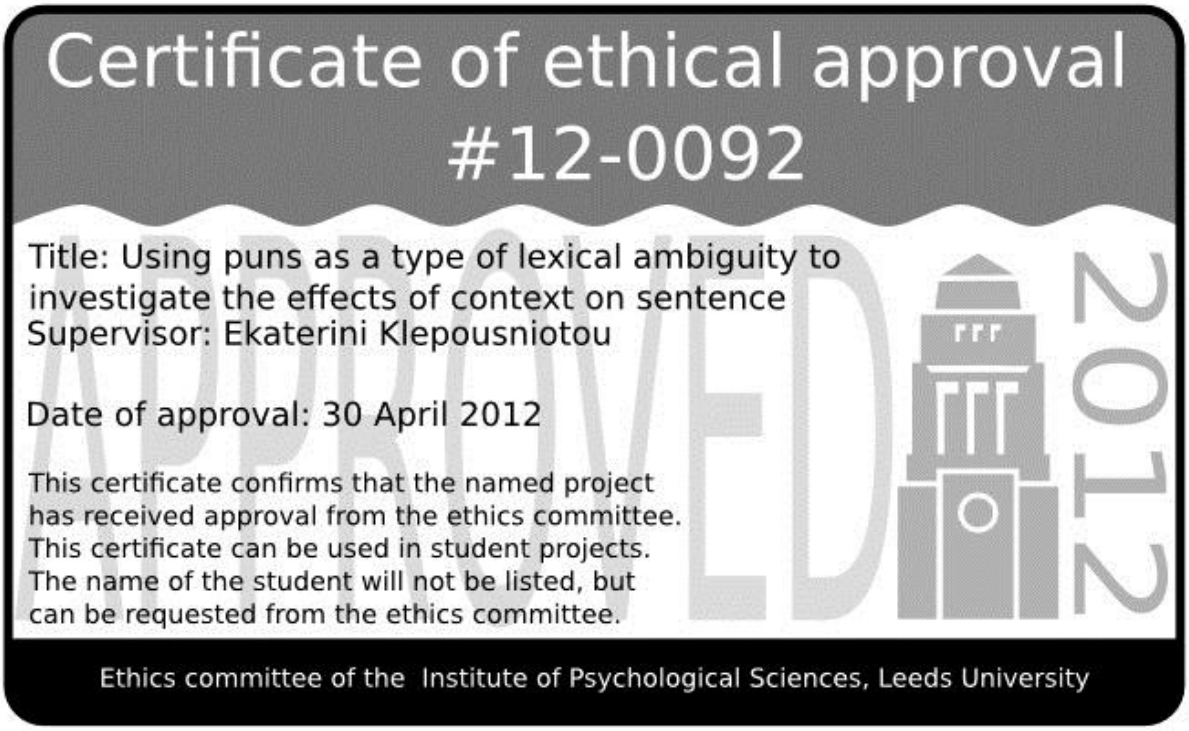
Appendix 1

(1a)



(1b)

Appendix 2

(2a).

A questionnaire was created which aimed to consult native speakers of English on the explicitness and clarity of all the puns. The responses indicated that the double meaning necessary for a pun to function is present in all the sentences. Participants were asked to indicate on a scale from 1 to 7 whether the sentence they read made them think both of the idiomatic meaning and the literal re-interpretation simultaneously. For example, one item of this questionnaire looks like the following:

	dinghy			**B**			**excess**
To commit suicide at sea is to go overboard.	1	2	3	4	5	6	7

At one end of the scale is the literal meaning of the idiom and the other end of the scale is for the idiomatic meaning. In the middle, under 4, there is a letter B which stands for the case when "Both meanings" are obvious. A pun is considered unsuccessful if participants provide either answer 1 or answer 7. No such items were found.

(2b).

The puns motivated by ambiguous words were included in the questionnaire which tested the idiom-motivated puns. The design and rationale of these items were identical to those described in 1a. A pun is considered unsuccessful if participants provide either answer 1 or answer 7. No such items were found. For example,

	Weight			**B**			**dollar**
In England, shops sell cat food by the pound.	1	2	3	4	5	6	7

Appendix 3

(3a)

A rating questionnaire which concentrates on the degree of compositionality of idioms was designed. Participants have to read a sentence in which an idiom is used in its normal figurative meaning.

For example,

"Unfortunately my little sister let the cat out of the bag."

Participants have to decide whether, and to what extent, the meanings of the individual words contribute to the overall figurative meaning of the idiom using a scale from 1 to 7. A choice of 1 indicates that the meanings of individual words do not contribute to the overall meaning, while a choice of 7 indicates that the meanings of the words contribute to the overall figurative meaning of the idiom in an obvious manner. The results of this questionnaire established the classification of the idioms into the 30 decomposable (mean responses above 4) and 30 non-decomposable idioms (mean responses below 4).

Internet address:

http://www.psyc.leeds.ac.uk/cgi-bin/projects/pgrad/KremenaK03/index.pl?1+0+0

(3b)

A second questionnaire was designed to rate the degree of familiarity of each one of these idiomatic expressions. Participants are asked to read the same sentences again but this time they had to indicate how familiar they were with the idiom. Participants used again a scale from 1 to 7 where 1 indicates that they are not familiar with the idiom at all, while 7 is selected if the participant thinks the meaning is very familiar. Internet address:

http://www.psyc.leeds.ac.uk/cgi-bin/projects/pgrad/KremenaK04/index.pl?1+0+0

Appendix 4

Decomposable idioms – double-meaning consistent contexts (puns):

Old bankers never die, they just **pass the buck.**

The young musician tried hard but couldn't **steal the show**.

Old colanders never die they just can't **take the strain.**

Progressive neurosurgeons always **keep an open mind.**

The artist wanted a cube but **had a mental block**.

I considered becoming a mountaineer but I couldn't **make the grade**.

We never get anywhere in geometry – only **go round in circles**.

I was **a** milkman but everything **turned sour.**

Old skiers never die, they just **go downhill.**

They kept their ballet dancers **on their toes.**

I was a balloonist but it didn't **get off the ground.**

I studied electrical engineering but I am still **in the dark**.

I can master Braille once **I've got a feel for it**.

I was a sprinter but I was **on the wrong track.**

Money for kitchen sink detergent is just money **down the drain**.

Life's like a shirt button – it only **hangs by a thread.**

I was destined for osteology – I could **feel it in my bones.**

I was a transplant surgeon, but **my heart wasn't in it.**

Toreadors resign when they can't **take the bull by the horns**.

I know a lingerie buyer who **gave his wife the slip.**

The careless lion-tamer **let the cat out of the bag**.

When a boxer practises in winter, he may be **out cold.**

Maths teachers are boring – they always **go off on tangents.**

The hair stylist knew she would **make waves.**

The old crab's relationship is **on the rocks.**

Life's like showers – one wrong turn and you're **in hot water**.

The cannibals gave the latecomers **the cold shoulder**.

This butcher does not seem to **mince his words**.

He couldn't fix the washing machine and **threw in the towel**.

The pilot's career is **up in the air.**

Decomposable Idioms – single meaning consistent idiomatic contexts:

It is never too tempting to pass the buck.

When we had guests children would never steal the show.

The transport service does not let us take the strain.

To progress we should keep an open mind.

When they referred to statistics I had a mental block.

Only a small minority of the students couldn't make the grade.

We can't decide today – we seem to go round in circles.

Soon after the accident their relationship turned sour.

Old painters never die, they just go downhill.

They kept their new employees on their toes.

Without enough money, the new company couldn't get off the ground.

I attended the seminar but I am still in the dark.

You can master anything if you've got a feel for it.

My tutor told me yesterday I was on the wrong track.

Money spent on fancy trinkets is just money down the drain.

Life is all very precious – it only hangs by a thread.

I was destined for greatness – I could feel it in my bones.

I was a good mechanic but my heart wasn't in it.

Managers resign when they can't take the bull by the horns.

The police followed him but he gave them the slip.

Unfortunately my little sister let the cat out of the bag.

A single slap from him can immediately knock you out cold.

Bookish people are boring – they always go off on tangents.

The new student knew she would make waves.

Sadly, her second marriage is on the rocks.

All those complaining e-mails can easily land you in hot water.

The pupils gave the newcomer the cold shoulder.

A frank person never tries to mince their words.

He couldn't do his maths homework and threw in the towel.

His career plans are up in the air.

Literal Targets	Idiomatic Targets	Unrelated Targets
cash	**dodge**	**smoke**
perform	**capture**	**bird**
drain	**suffer**	**wing**
brain	**flexible**	**bowl**
cone	**halt**	**media**
slope	**attain**	**fluid**
sphere	**static**	**stove**
lemon	**spoil**	**essay**
slide	**decline**	**soup**
stretch	**anxious**	**plastic**
sky	**succeed**	**demon**
star	**ignorant**	**trend**
finger	**skill**	**match**
trail	**error**	**snake**
pour	**waste**	**shake**
needle	**risk**	**bath**
joint	**perceive**	**crouch**
chest	**dislike**	**tree**
cow	**brave**	**cream**
skirt	**chase**	**shell**
feline	**reveal**	**arrow**
ice	**smack**	**sauce**
algebra	**digress**	**hen**
ocean	**fascinate**	**spasm**
stone	**split**	**bureau**
wet	**worry**	**kid**
blade	**avoid**	**foam**
meat	**honest**	**loud**
wipe	**defeat**	**code**
fly	**dim**	**pat**

Non-decomposable idioms – double-meaning consistent contexts (puns):

I was a carpenter but it **went against the grain.**

In medical matters it's the nurses who **call the shots.**

I wasn't a yachtsman as I didn't **know the ropes.**

To commit suicide at sea is to **go overboard.**

The chefhas to make sure he doesn't **cook the books.**

To communicate with a fish, you need to **drop a line.**

The young jockey resigned because he couldn't **hold his horses**.

Babies don't like baths because they **get them into a lather.**

The success of the new bank is **on the cards**.

Management at the post office always **push the envelope**.

When he was sentenced to the guillotine he **lost his head**.

I fired my masseuse because she **rubbed me the wrong way**.

Old cleaners never die they just **bite the dust.**

The arts students decided to **paint the town red**.

The lumberjack wanted advice from someone with **no axe to grind.**

The stuck-up chef was left with **egg on his face**.

A bunch of meteorologists got together to **shoot the breeze**.

The lady threatened to **take the laundrette to the cleaners**.

The suicide bomber said the explosion **blew his mind**.

A bad shoemaker's assistant **was given the boot.**

He didn't pay his orchestra and had to **face the music.**

The crooked greengrocer found himself **in a pickle**.

Two surgeons joking about operations will **have each other in stitches**.

I worked in a delicatessen but I couldn't **cut the mustard**.

The swimmer quit as he would **go off the deep end**.

Old owls never die, they just don't **give a hoot**.

Sailing is a sport that does not **float my boat**.

Butchers' cutting remarks can **get customers in a stew.**

Old gardeners never die they **kick the bucket**.

Chemistry students are never **out of their element**.

Non-decomposable idioms – single meaning consistent contexts:

I worked on Sundays but it went against the grain.

I wanted to trade but I didn't know the ropes.

It's easy for primary school pupils to go overboard.

He looks for accountants who are unlikely to cook the books.

To stay in touch with the family, just drop a line.

The young manager resigned because he couldn't hold his horses

Couples don't like quarrels because they get them into a lather.

The success of the new play is on the cards.

Management at work always push the envelope.

When he won the national lottery he completely lost his head.

I fired my assistants because they rubbed me the wrong way.

Like it or not we all bite the dust.

Yesterday the boys decided to paint the town red.

She acted solely out of concern with no axe to grind.

The non-attendance left the boss with egg on his face.

A bunch of students got together to shoot the breeze.

He wished he could take his company to the cleaners.

The story I told her absolutely blew her mind.

After the scandal he was given the boot.

He didn't submit his essay and had to face the music.

The crooked policeman found himself in a pickle.

Two friends joking about puns will have each other in stitches.

I wanted to do research but I couldn't cut the mustard.

After a few drinks he'd go off the deep end.

We all need to learn not to give a hoot.

Watching horror movies before sleep does not float my boat.

Cutting remarks can always get customers in a stew.

Old farm animals never really kick the bucket.

Guests should never feel out of their element.

Literal Targets	Idiomatic Targets	Unrelated Targets
circle	**odd**	**coat**
inject	**reign**	**lend**
knot	**knack**	**paddock**
dinghy	**excess**	**tissue**
meal	**alter**	**pocket**
string	**mail**	**lamp**
ride	**calm**	**wash**
soap	**tense**	**dish**
earn	**feasible**	**mud**
stamp	**grow**	**mile**
sword	**panic**	**pearl**
muscle	**anger**	**ought**
dirt	**grave**	**wire**
brush	**fun**	**text**
chop	**profit**	**priest**
yellow	**stupid**	**screen**
wind	**gossip**	**cloth**
broom	**trick**	**fleet**
gale	**shock**	**glimpse**
lace	**sack**	**knit**
sing	**blame**	**mixture**
jar	**dilemma**	**visual**
thread	**laugh**	**wisdom**
seed	**expert**	**gang**
jump	**yell**	**ankle**
shout	**ignore**	**pub**
row	**joy**	**drama**
boil	**hurt**	**tunic**
barrel	**coffin**	**modest**
atom	**comfort**	**slug**

Filler sentences with puns:

Employers like their mechanics to be geared up.

The fine print is usually a clause for suspicion.

People who like yoghurt are well-cultured.

After the test drive, the car salesman drove home his point.

The size a dieter would like to get to is the sighs of relief.

The astronauts stopped dating because they needed their space.

Strippers are bad investors as they tend to lose their shirts.

Patients usually feel better after receiving hand transplants.

Their business plan for a flower shop was cut and dried.

Two duchess arguing about their husbands decided to duke it out.

In the old days a suspended sentence was hanging.

Those who make sinks often feel washed out.

She was given a violin lesson for free, with no strings attached.

He bought a donkey just to get a kick out of it.

They are a fastidious couple – she is fast, he is tedious.

They hid in a sauna where they could sweat it out.

After dating the goalie for a while, she realised he is a real keeper.

Those who experiment with thin ice will achieve a breakthrough.

He slipped into a manhole with a loaded gun, but then blew his cover.

Six is afraid of seven because seven eight nine.

Erasable pens were a good idea on paper.

Molecules boiling points vary to some degree.

The farmer brought some milk to church to be pastorized.

It's hard for a depressed turtle to come out of its shell.

The decision to shoot more wolves caused howls of protest.

A horse is a very stable animal.

Straw hats are no longer in their hay day.

I used to be a tap dancer until I fell in the sink.

People think that writing long stories is a novel idea.

I didn't know which hammer to get, But I think I nailed it.

We didn't know she had a dental implant until it came out in a conversation.

A tight-rope walker enjoys being on-line.

On Valentine's day many people take heart.

People in medieval days were always hanging out by the gallows.

When his ship ran aground, he couldn't fathom why.

If money talks, we do not really need bank tellers.

The skeleton went to a party but had no body to dance with.

The railway constructions are on track.

The average ghost is mean spirited.

Old deans never die, they just lose their faculties.

The science teacher says the globe means the world to her.

A thief who stole a calendar got twelve months.

I used to hate maths before I realised that decimals have a point.

A new type of broom is sweeping the nation.

Using fingers to count is a digital calculator.

If you give managers an inch, they think they are a ruler.

He took a gun to his watch because he wanted to kill time.

I usually take steps to avoid elevators.

Maths teachers call retirement the aftermaths.

He was stealing from a blood bank, but he was caught red-handed.

Contacts are easy to lose, so keep your eyes on them.

The job to die for comes with a killer boss.

Graveyard workers should really dig their jobs.

When the elevator broke I was downcast.

My job at the concrete plant seems to get harder and harder.

He has been a jogger for three years running.

To some marriage is a word, to others – a sentence.

Don't trust people who do acupuncture, they are back-stabbers.

Old mediums never die – they just give up the ghost.

Noteworthy musicians are very composed.

<u>Filler sentences without puns:</u>

A small amount of this paint goes a long way.

Give your brother my regards when you see him.

We have to get to the root of the problem.

Prevention plays a central role in traditional medicine.

She managed to calm him down and seek help.

Both candidates spent last month courting the media.

She has very modern ideas about educating her children.

The delay is due simply to the volume of traffic.

We take the view that it would be wrong to interfere.

In case of emergency, break the glass and press the button.

It was a performance of verve and vitality.

The money was collected for a specific purpose.

There's no point getting into a panic about the exams.

Two regiments were sent to garrison the town.

For certain personal reasons I shall not be able to attend.

He passed the rope around the post three times to secure it.

Each student's points were totalled and entered in a list.

He still has a cloud of suspicion hanging over him.

The treatment they gave him did him more harm than good.

I think you should go back to your original plan.

She towers over other dancers of her generation.

His savings were a comfortable cushion against financial problems.

Classical dance in its purest form requires symmetry and balance.

The land is used by local people to graze their animals.

I showed my pass to the security guard and he waved me through.

The survivors were adrift in a lifeboat for days.

She has a remarkable inner strength.

We had to stop for breath before we got to the top.

Remove the skins by soaking the tomatoes in hot water.

Their latest single represents a new departure for the band.

They were able to share their common joys and griefs.

They'll be offended if you do not go to their wedding.

I had a flick through the catalogue while waiting.

The meeting was hyped up in the media as an important event.

He's been on the computer all morning, chatting to his friends.

The injured were carried away on stretches.

I am really concerned about my spiritual welfare.

She was charged with credit card fraud.

I was pinched for dangerous driving.

You must have wiped off that programme I recorded.

A lecture from my parents now would just finish me.

She always wears her hair pinned back.

The big corporations are bleeding some of the small countries dry.

There is not a grain of truth of what she says.

He travelled from town to town selling his wares.

He caught a whiff of perfume as he leaned towards her.

The story was reported in the press and on television.

He was very insecure about his appearance.

I believe you have a complaint against one of our nurses.

Their marriage was trumpeted as the society marriage of the year.

This dictionary gives phonetic transcriptions of all headwords.

The Army is auctioning off a lot of surplus equipment.

Below him was nothing but a black void.

He called her the foulest names imaginable.

We cannot guarantee adequate supplies of raw materials.

The star of the show was a young Italian singer.

We spent the whole evening discussing domestic trivia.

Now she had him in her clutches, she wasn't going to let go.

A group of kids started a pick-up game of basketball.

A welcoming fire was burning in the fireplace.

Non-Words	Non-words	Non-Words
lerps	**smoob**	**drine**
vuct	**claivs**	**swuff**
norve	**fruzz**	**clulls**
jamped	**plines**	**psyth**
nurf	**daves**	**wogged**
clyst	**shabes**	**bloys**
owse	**kril**	**flib**
landge	**derse**	**vuked**
spugs	**braff**	**smool**
jadge	**flized**	**sharn**

sproil
bruint
polks
klus
bungal
pendge
brenge
glact
crus
smenth
dorce
yarks
chich
ganks
phecks
cabes
gleut
hapes
ments
malps
scrons
zamped
crogue
vonce
spabe
dake
beags
durnt
coved
slafe
momps
brive
kib
nirm
zurp
slarfs
plaped
scalvs
crarc
gevved
stask
blit
clis
snace
twans
stuilt
dored
wronk
stends
nuds
prese
vames
pheem
whamp
klupes
klou
vaives
snibs
gect
draff
woffed
pheek
zouls
wat
smase
treng
plause
mawk
yeel
gloals
shruff
cleald
daught
pheech
bliche
pigued
spleese
phuv
glells
flodd
deaned
seffed
hurns
reace
frope
tib
blinch
thobs
rolds
gnoped
phreen
slonce
gopse
crong
crumed
soast
carce
prith
cloams
tweigh
peph
stusk

flaum	**glaul**	**nirs**
droles	**croafs**	**fusk**
clift	**lods**	**flane**
bymn	**skarc**	**plev**
stiest	**skop**	**stad**
klense	**frilks**	**drarps**
foafs	**swalt**	**snuth**
jitts	**dondge**	**folge**
crined	**crench**	**stib**
neets	**mave**	**flerm**
drungs	**cype**	**plonn**
vild	**slobes**	**neidge**
zumf	**flell**	**spance**
blufts	**ribed**	**gluse**
hule	**shales**	**rond**
lault	**chole**	**farch**

Appendix 5

(5a)

A rating questionnaire was designed to assess the degree of relatedness between the two alternative meanings/senses of ambiguous words. Participants are given pairs of sentences to read. One of the sentences of the pair is the dominant meaning consistent sentence and the other is the subordinate meaning consistent sentence.

For example,

1. This diet immediately guarantees that you lose a pound.

2. The Euro has massively strengthened against the British pound.

Participants are asked to use a scale from 1 to 7 to indicate how related they perceive the two meanings of 'pound' exemplified in the above two sentences. If they think the meanings are not related at all they are instructed to select 1, and if they think the two meanings are very related they need to select 7.

Internet address:

http://www.psyc.leeds.ac.uk/cgi-bin/projects/pgrad/KremenaK01/index.pl?1+0+0

(5b)

Participants are asked to read the same pairs of sentences again (e.g. This diet immediately guarantees that you lose a pound./The Euro has massively strengthened against the British pound.) but this time they have to indicate how familiar they are with each one of the meanings individually. Participants use again a scale from 1 to 7 in which 1 indicates that the particular meaning is not familiar at all, while 7 would be selected if the participant thinks the meaning is very familiar. The more dominant meaning is expected to be more familiar to participants.

Internet address:

http://www.psyc.leeds.ac.uk/cgi-bin/projects/pgrad/KremenaK02/index.pl?1+0+0

Appendix 6

Polysemous words – double-meaning consistent sentences (puns):

Golfers hate cake because they might get a **slice**.

In England, shops sell cat food by the **pound**.

Everyone in town had low IQ's, the population was **dense**.

An experienced waiter can always give you a good **tip**.

If you are what you eat, I'd stay away from **nuts.**

This beverage says non-alcoholic, but I want to see the **proof.**

The prince with a bad tooth got a **crown**.

Optometrists make good presidents because they are people with good **vision.**

I was a baker, but I didn't make enough **dough**.

I left the computer shop because I didn't have the **drive**.

I was an athlete but there were too many **hurdles**.

I was a gravel merchant but I didn't have the **grit.**

They arrested me for stealing adhesive but the charges didn't **stick**.

He puts strings on electric guitars – a job that takes **guts.**

She was fired from the bakery for putting her hair in a **bun.**

I was so hungry the dentist gave me a **plate**.

I met her at an internet cafe but we didn't **click.**

To make really good chocolate, one needs to raise the **bar**.

That is an unusually cool chair – it **rocks**.

He entered the dentist's office and lost his **nerve**.

The inventor of a hay baling machine made a **bundle.**

All companies for making suits need common **ties.**

The origami company next door is about to **fold.**

Old basketball players never die, they just **dribble**.

That old funeral director is a disgusting little **worm**.

With customary bravado, the turkey announced it was **game**.

The nimble plumber confessed he hadn't done a **tap**.

The Headmaster turned to sweets because he loved the **cane**.

When pumas get dangerous, rangers go on a wildcat **strike**.

The chicken coop needs one more **wing**.

I was sober until I was hit by the **punch.**

Polysemous words – Dominant-meaning consistent sentences:

Mum's cakes are so tasty I get a second slice.

The euro has massively strengthened against the British pound.

I have never ever seen a forest so dense.

When eating out I always leave a very generous tip.

For dinner today there's a cake decorated with chocolate and nuts.

Cases are usually easier and faster when there is conclusive proof.

When Elizabeth became a queen she got a crown.

When she is angry he moves outside her field of vision.

Mary used a secret ingredient for her biscuits' dough.

I was sure she would do well – she has tremendous drive.

He was winning but the horse fell at the final hurdle.

During the winter, we spread icy roads with salt and grit.

The new adhesive you bought yesterday was useless – it wouldn't stick.

I'll happily cook all the fish if someone removes the guts.

For breakfast she would usually have a coffee and a hot bun.

He prepares nice sandwiches and serves them on a plate.

The man raised the camera and I heard a click.

Only very few young kids will refuse a nice candy bar.

I like that chair because it gently rocks.

The injury caused severe damage to the optic nerve.

In his small arms, he tightly held a tiny bundle.

John finds it hard to do his school ties.

He did the ironing and had only one sweater to fold.

It's not unusual for old people to dribble.

Children are scared even of a small worm.

He used to enjoy going hunting for big game.

He was irritated by the noise of the dripping tap.

They introduced some new crops such as the sugar cane.

Air traffic controllers have threatened to come out on strike.

The bird cannot fly because it has an injured wing.

He didn't mean to but he delivered a knockout punch.

Polysemous words – Subordinate-meaning consistent sentences:

Professional golfers know how to avoid getting a slice.

This diet guarantees that you immediately lose a pound.

She always treats her men as if they were dense.

Any hint on saving money is considered a good tip.

I can say that most of my friends are complete nuts.

This is very strong alcohol as it's indicated by the proof.

The NHS charges three hundred pounds for a crown.

Many consider the new president to be a leader of vision.

John wanted to buy a car but didn't have the dough.

The early computers had only 1 GB of hard drive.

To get her parents' agreement was the last big hurdle.

I was a teacher but I didn't have the grit.

Try as they might, the police couldn't make the charges stick.

To quit a well-paid job requires you to have the guts.

When she was younger she liked wearing her hair in a bun.

I know many old people who enjoy wearing a plate.

We met at a Christmas party but didn't really click.

For me, he was a leader whose example set a high bar.

The new Hollywood production of the film rocks.

I wanted to try parachuting but lost my nerve.

Their shiny new car must have cost them a bundle.

All branches of the corporation have close ties.

Rumour has it that Cadbury's is about to fold.

All great basketball players know how to dribble.

They abhor him and consider him a worm.

They were looking for someone fearless who was game.

While she was dressing he did a phone tap.

In the past some teachers punished pupils with the cane.

In the end the army decided to launch a pre-emptive strike.

The children's ward of the hospital is in the west wing.

In my time real ladies used to drink only punch.

Dominant Target:	Subordinate Target:	Unrelated Target:
piece	**curve**	**poetry**
weight	**dollar**	**frame**
compact	**dull**	**heaven**
restaurant	**advice**	**silence**
cracker	**weird**	**waltz**
document	**percentage**	**dice**
throne	**dentist**	**whisper**
blind	**dream**	**draft**
flour	**coin**	**pump**
disk	**energy**	**flag**
runner	**hardship**	**ghost**
sand	**courage**	**prize**
glue	**valid**	**shower**
organ	**dare**	**gift**
butter	**ribbon**	**freeze**
spoon	**braces**	**wistful**
snap	**suit**	**stump**
sugar	**norm**	**dispute**
sway	**perfect**	**angel**
cell	**bold**	**cotton**
pile	**fortune**	**bitter**
shirt	**network**	**frighten**
bend	**bankrupt**	**honey**
leak	**bounce**	**slight**
fish	**sly**	**horn**
pheasant	**zealous**	**nectar**
sink	**device**	**chapel**
candy	**beat**	**dome**
fist	**cocktail**	**clover**
protest	**violent**	**plug**
feather	**domain**	**comet**

Homonymous words – double-meaning consistent sentences (puns):

Old lawyers never die, they just lose their **appeal**.

When the ancient wall sculptures were finished, it was a **relief**.

It is advisable for lumberjacks to keep a problem **log**.

You pay your psychiatrist with a sanity **check**.

A doctor's cane is the so-called medical **staff**.

The inventor of After Eights must have made a **mint**.

The innumerate resident of Monte Cristo couldn't **count**.

The hungover footballer threw up on the team **coach**.

The fungus had to admit it didn't fit the **mould**.

The impoverished flea bought an expensive clock on **tick.**

The Arab was disappointed with the size of his **date**.

Gordon's advice for the new chef was **sage**.

The weatherman in Ancient Rome predicted all **hail**.

The convicts escaped by using the prison's **file**.

I can smell fish – said the parrot sitting on a **perch**.

The gang of drunk sailors ran out of **port**.

He wanted something with his beans so I suggested a **toast**.

The drunk badminton players made a terrible **racket**.

The out of breath stripper had done another **lap**.

For Thanksgiving this year the dictator has demanded **Turkey**.

In our farm during branding, cowboys have sore **calves**.

The old carpenter down the road knows the **drill**.

I was a nun but was expelled for my dirty **habits**.

A cross-eyed teacher can't control his **pupils**.

Dermatologists do not have to be always **rash.**

He wanted to jump off the precipice which wasn't a **bluff**.

The competitive calendar makers decided to steal a **march**.

The formula one driver was sacked because of his **race**.

All the footballers loved the fancy-dress **ball**.

If you know where Stalin's buried, you'd know a communist **plot**.

Homonymous words – Dominant-meaning consistent sentences:

If you are suspended you have the right to appeal.

When he left, we all breathed a sigh of relief.

For a big fire we need a very thick log.

All the car really needs is a routine check.

The school has fifty full-time members of staff.

I like After Eights because you can taste the mint.

She is young but she can already count.

This time round they decided to take the coach.

The cheese in the fridge was all covered in mould.

You get Lyme disease when bitten by a tick.

He didn't come along because he went on a date.

He liked his dishes with a lot of sage.

We drove through rain, sleet, snow and hail.

I keep my scripts in a green file.

When the foxes cried the birds would all simply perch.

The badly battered ship spent four days in port.

When they were young they used to love cheese on toast.

When he played squash he broke many a racket.

She sat quietly with her hands in her lap.

One of the countries Bulgaria borders on is Turkey.

The neighbour's cow gave birth to a single calf.

Carpenters nowadays know how to use an electric drill.

Once you start biting your nails it easily becomes a habit.

After he retired he only teaches private pupils.

He obviously meant to shoot him and it wasn't a bluff.

Chocolate makes me come out in a rash.

My friend's birthday is at the end of March.

He is already training every day for the big race.

Young children love playing outside with a ball.

I like a book when it's well-organised in terms of plot.

Homonymous words – Subordinate-meaning consistent sentences:

The Beatles have never really lost their appeal.

The column at the temple was covered with sculptured relief.

It is the captain's duty to keep the ship's log.

She always pays for her hotel rooms by check.

When outside, some elderly people prefer to use a staff.

His new sports car must have cost him a mint.

He'll inherit his father's title of a count.

He found maths hard so they looked for a private coach.

To cast bronze statues you need a sturdy clay mould.

She never saved so she got things on tick.

My little sister loved the taste of a fresh date.

He was very clever and his advice sage.

When you see us outside you just hail.

To carve the window frame he needs a file.

As a young lad he used to love fishing for perch.

Such a nice steak requires a glass of port.

After they signed the contract the committee made a toast.

His mother gets angry when he makes a racket.

They suddenly overtook him on the last lap.

At Christmas one has got to have roast turkey.

They have to amputate immediately below the calf.

To improve your grammar you can use that drill.

For the next fancy dress party I'll get a nun's habit.

These drops are necessary to dilate your pupils.

Please think twice before you do anything rash.

The fishermen's village is a huddle of shacks on a bluff.

At dawn we will all go on another march.

He admires the Canadians as a hardy and determined race.

The princess decided to organise a big ball.

She is dreaming of a big house with a vegetable plot.

Dominant target:	Subordinate target:	Unrelated target:
plead	**attract**	**contain**
relax	**décor**	**silk**
wood	**journal**	**grand**
examine	**warrant**	**tape**
worker	**pole**	**ardent**
sweet	**wealth**	**ruin**
eighty	**duke**	**trumpet**
bus	**teach**	**mood**
mildew	**shape**	**stress**
bug	**borrow**	**apron**
movies	**fruit**	**carbon**
bush	**wise**	**fog**
storm	**tribute**	**clock**
drawer	**carpenter**	**rake**
branch	**lake**	**phone**
dock	**brandy**	**lotion**
bread	**proposal**	**push**
tennis	**noise**	**barn**
thighs	**relay**	**dove**
oriental	**breast**	**comb**
veal	**leg**	**marriage**
tool	**practice**	**sew**
addict	**monk**	**clap**
student	**eyelid**	**hotel**
itch	**impulse**	**bin**
fake	**cliff**	**dose**
april	**soldiers**	**rusk**
track	**colour**	**fresh**
round	**dance**	**studio**
fiction	**patch**	**sum**

Fillers – Puns:

The two giraffes in the race were neck and neck.

He was hired at 70 and he was put in a senior position.

Superfluous refers to a bad case of the flu.

He had trouble making tents and got himself into a flap.

A rule of grammar – double negatives are a no-no.

It's great to be a watch-maker – you make your own hours.

My advanced geometry class is full of squares.

At rifle competitions, the best team always wins by a long shot.

A ham walked out of the hospital and said I'm cured.

Old photographers never die, they're just out of the picture.

Artists are colourful people who draw on their emotions.

Manufacturing contact lenses in harder than meets the eye.

When I couldn't find my thesaurus I was at a loss for words.

Small dogs with rich mistresses often sit in the lap of luxury.

He got a job in a factory making needles, but soon got stuck.

There is a growing body of obesity research.

Global warming will be discussed next week – it's quite a heated topic.

She had a sweet disposition until the bitter end.

Though humble in secular matters, the minister had an altar ego.

Horses eat best when they don't have a bit in their mouth.

A new lumberjack's union was started by a splinter group.

Old musicians never die, they are just disconcerted.

Match makers like to strike up a light conversation.

Losing your head in an emergency is a no brainer.

Worms are despicable – they lack the backbone to stand up.

A janitor with a broom in hand swept her off her feet.

Two needles of different length could never see eye to eye.

Librarians are always going everything by the book.

For a long time black holes were a dark secret.

He quit his job designing clothes and became a man of the cloth.

The inventor of the balloon was full of hot air.

I don't think I need a spine – it's holding me back.

I used to be a banker but I lost interest.

I used to be addicted to soap, but I am clean now.

The dead batteries were given free of charge.

When fish are in schools they sometimes debate.

The harm caused by the sibling rivalry is relative.

After working for twenty-four hours straight he called it a day.

My new theory of inertia isn't gaining momentum.

England doesn't have a kidney bank, but it has a Liverpool.

The answers for the geology test were written in stone.

If you don't pay your exorcist, you get repossessed.

Erasable pens are a good idea on paper.

Some burglars are often looking for windows of opportunity.

In parking lots, arguments often start from scratch.

I heard a joke about amnesia but I forgot how it goes.

Working as an elevator manager has its ups and downs.

She owns twenty shoe shops and is very well-heeled.

It's true I'm obsessed with soap but don't rub it in my face.

She stole a brooch but they couldn't pin it on her.

I probably have blond spots but I don't see them.

After he bought a mirror he became very reflective.

He had a photographic memory that was never developed.

Oil executives are always using crude language.

The phone call interrupted my nap and never got the rest.

The military head is seeking more arms.

A hairdresser for a film star had a brush with fame.

When scissors were first invented they were on the cutting edge.

A pessimist's blood type is always B-negative.

If all women left the country there would be a stagnation.

<u>Fillers – non-pun:</u>

The room was damp and the paper was peeling off.

Venice is a beautiful city full of culture and history.

We managed to beg a meal from the cafe owner.

If you get up early, try not to disturb everyone else.

I started to feel afraid of going out alone at night.

There will be a chance for parents to look around the school.

There is a general recognition of the urgent need for reform.

We've told our daughter not to speak to strangers.

The baby's whole body was covered in small red dots.

He looks exactly the same as he did at school.

Marie changed her name when she got married.

His younger brother is not much of a companion for him.

The wedding was a very grand occasion.

The memory of that day will haunt me forever.

He could no longer hold back his tears.

Darker colours are more practical and don't show stains.

After a while his eyes adjusted to the dark.

She caught a secret smile flitting between the two of them.

I have never known her to betray a confidence.

The shed comes in sections that you assemble yourself.

Several people described seeing strange lights in the sky.

The term I used was meant to be purely descriptive.

Large numbers of soldiers deserted as defeat became inevitable.

He traces his line of descent from the Stuart kings.

There was a loud bang and then all hell broke loose.

The goal was scored midway through the first half.

Their foreign policy is based on the principle that might is right.

We have struggled mightily to win back lost trade.

The infected cells then migrate to other areas of the body.

The nearest bank is about half a mile down the road.

She guided us through the busy streets to the cathedral.

She had feelings of guilt about leaving her children.

The advertisements depict smoking as glamorous and attractive.

Tragedy struck the family when their son committed a suicide.

Confess your sins to God and he will forgive you.

She was a skilful speaker and knew how to work a crowd.

The actors inspired the kids with their enthusiasm.

My father's death had a profound effect on us all.

A fall in unemployment will help restore consumer confidence.

It's difficult to define the exact nature of this problem.

Teachers have expressed concern about the new curriculum changes.

People watched in horror as the plane crashed to the ground.

The competition is open to both teams and individuals.

The new building was completely destroyed by the fire last night.

The government plans to create new jobs for the young.

The product was created in response to customer demand.

Students were involved in violent clashes with the police.

He was a solitary man who avoided the society of other men.

She crouched in the dark, too frightened to reveal herself.

I will be eternally grateful to you for helping me out.

At that time children were regularly beaten for quite minor offences.

I had another helping of ice-cream out of pure greed.

He was accused of obtaining property by deception.

I suspect that he was dismissed for political reasons.

I heard his heavy tread on the stairs.

He would have loved his portrait painted in uniform.

There is a need for greater diversity and choice in education.

Everyone admires his strength of character and determination.

It horrified her to think that he had killed someone.

She fell off the ladder and broke both her arms.

The plan makes no allowance for people working at different rates.

The howling wind sounded like the wailing of lost souls.

A thick skin had formed on the top of the milk.

She went to Hollywood in search of fame and fortune.

The newspaper continues to defend its publication of the photographs.

He wanted to be rich but it was an impossible dream.

The charity has been an agent for social change.

It was generous of him to offer to pay for us both.

The bird is too tame now to survive in the wild.

It was an astute move to sell the shares then.

Teaching children with special needs requires patience and understanding.

Settling the dispute required great tact and diplomacy.

Her version of events was accepted without question.

We have to tolerate each other's little foibles.

Many unemployed people experience feelings of isolation and depression.

Mark has two children to support from his first marriage.

It was just a piece of harmless frivolity.

He was making a real effort to be nice to her.

The old and new buildings blend together perfectly.

I associate the smell of baking with my childhood.

The meat is served with salad or assorted vegetables.

I'd completely forgotten about the money he owed me.

Getting out of the city at the end of the weekend keeps me sane.

She put forward some reasons for abandoning the plan.

Twelve hours later she was all smiles again.

His talents are not fully appreciated in that company.

A hushed courtroom listened as the boy gave evidence.

Most candidates will be out on the hustings this week.

She only remembered details of the accident under hypnosis.

He became almost hysterical when I told him.

He already had an idea for his next novel.

The brochure should give you a good idea of the hotel

He needed to be taken down a peg or two.

The whole family were penned up in one room for a whole month.

One of the penalties of fame is loss of privacy.

She regards living in New York as a penance

You must be ready to leave at a moment's notice.

When he said that, something snapped inside her

He felt angry at the injustice of the situation.

Fish oils are less saturated than animal fats

I need time to get my wind back after that run

She stretched across the table for the butter.

They're sending an engineer to fix the phone.

Huge pipes funnel the water down the mountainside.

Local councillors have a duty to serve the community.

At one stage it looked as though they would win.

I heard sounds of a desperate struggle next door.

Rivers of molten lava flowed down the mountain.

Everything was covered with a thick layer of dust.

I only need one more card to complete the set.

There is little hope that they will be found alive.

It was pure chance that we were both there.

I would work better if I had some peace and quiet

A bell tinkled gently as the door opened.

She went on to catalogue a long history of disasters.

There was no respite from the suffocating heat

The attack added a new urgency to the peace talks.

She said it without a hint of irony.

He has the look of a man who means business.

Fashions in art and literature come and go.

Non-word	Non-word	Non-word
rop	**blused**	**gloach**
jaused	**neech**	**pove**
clett	**slaib**	**smow**
snurfs	**molve**	**doths**
beave	**frawl**	**dawls**
geente	**frult**	**staids**
wofts	**severy**	**gruct**
whols	**dern**	**sheam**
flince	**heen**	**spink**
stilch	**lafe**	**baith**
fusk	**durde**	**maffed**
plang	**gnach**	**tratts**
vapse	**scauf**	**slast**
fenth	**spush**	**thean**
trebe	**gnake**	**scauce**
tarb	**fowd**	**phown**
crolt	**thrail**	**frace**
pract	**droad**	**deace**

mesque	**plect**	**stused**
flane	**pawst**	**fark**
plail	**bief**	**breap**
chonc	**gloked**	**bringe**
micked	**gurbe**	**frawk**
yusks	**blurge**	**zix**
wumps	**tunge**	**drolt**
floul	**speem**	**drust**
plod	**kilp**	**prot**
smount	**throg**	**bloap**
purp	**slarts**	**smarge**
zool	**sleace**	**broon**
slont	**cleps**	**smeap**
creum	**goaks**	**smens**
frides	**smecs**	**kisp**
boathe	**wrenge**	**strak**
swoust	**wouse**	**scoles**
yelb	**blage**	**sloack**
snaids	**gault**	**pronn**
toaf	**kefts**	**splift**
dunge	**crent**	**snound**
spresh	**nesk**	**jawled**
slomes	**slear**	**chonze**
gronce	**stome**	**shreef**
swerts	**cauved**	**stebbs**
trudge	**launde**	**snalph**
frenes	**stroul**	**dirp**
prues	**blunge**	**gnerd**
weff	**snarc**	**blid**
ciff	**pess**	**craste**
cluft	**zoone**	**critts**
pudd	**stulp**	**phiff**
poy	**cleeth**	**vev**
croosh	**froin**	**frew**

spolt	**knatch**	**stetch**
rawned	**vauge**	**strebb**
dwalls	**snause**	**droved**
foads	**crink**	**sheebs**
frenze	**gorbs**	**surked**
slonge	**prikes**	**sponch**
kaush	**bloaf**	**chulbs**
glike	**scrooge**	**splow**