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Textual emotion potential, fiction feelings, and immersion: an fMRI study testing the neurocognitive poetics model of literary reading

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Abbreviations

ACC	anterior cingulate cortex
aTL	anterior temporal lobe
BA	Brodmann area
dlPFC	dorsolateral prefrontal cortex
dmPFC	dorsomedial prefrontal cortex
EEG	electroencephalogram
ELN	extended language network
fMRI	functional magnetic resonance imaging
GLM	general linear model
IFG	inferior frontal gyrus
L1	the native language
L2	the second language
mCC	mid-cingulate cortex (= dorsal ACC)
MEG	magnetoencephalogram
MVPA	multivariate pattern analysis
OFC	orbitofrontal cortex
PCC	posterior cingulate cortex
PHC	parahippocampal cortex
SMG	supramarginal gyrus
STG	superior temporal gyrus
STS	superior temporal sulcus
TOJ	temporal-occipital junction
ToM	Theory of Mind
TPJ	temporal-parietal junction
vmPFC	ventromedial prefrontal cortex
VWFA	visual word form area

Summary

Reading is a complex higher-order cognitive activity unique to human beings, which transmits the sense, feeling, tone, and intention of the writer (Oatley, 1995) and brings pleasures (Brewer & Lichtenstein, 1982; Nell, 1988). Advancing our knowledge about emotion processing in literary reading through research is essential because the emotional impact of reading benefits children's vocabulary (Cunningham & Stanovich, 1998), grammar, text comprehension capabilities (Cipielewski & Stanovich, 1992; Cox & Guthrie, 2001), and furthers positive attitude towards, motivation to and achievement in reading (McKenna, Kear, & Ellsworth, 1995). However, the neurocognitive aspects of emotion processing in literary reading are still hardly understood. This dissertation aims to investigate the affective processing mechanisms during literary reading that bring about enjoyment at different levels – from smaller to larger units of textual structure. The dual-route neurocognitive poetics model of literary reading by Jacobs (2011, 2014) is referred to as a guidance for the author to pose relevant research questions and to test key assumptions of the model. The neurocognitive poetics model consists of a fast, automatic route for implicit processing of texts, focusing on "background" elements, and a slower route for explicit processing of "foregrounded" text elements. The foci of this dissertation include: 1) the lexical level, at which single words are processed; 2) the inter-lexical level, at which specific relationships between words – independently of syntax structure – come into play; 3) the supra-lexical level, at which the emotional impact originates beyond the impact of the representation of single constituting words. This dissertation also tests four possible hypotheses concerning neural networks associated with affective response during literary reading: 1) the neural-reuse hypothesis (Anderson, 2010; Ponz et al., 2013); 2) the classical psycholinguistic hypothesis; 3) perspective simulation and identification (Oatley, 1995, 1999); and 4) embodied or grounded emotion (Niedenthal, 2007).

For this dissertation, an fMRI and several behavioral experiments were conducted. In the fMRI experiment, 120 text passages from the Harry Potter book series were presented. The passages presented contained three orthogonal factorial dimensions: Emotion, Supra-naturalness, and Language. The manipulation at the Emotion dimension featured 40 fear-inducing, 40 happiness-inducing, and 40 neutral passages, with an overall large variance of affective valence and arousal values. The categorization of the passages in this dimension relied on a pilot passage rating study on the emotional dimensions of valence, arousal, fear, and happiness. The Supra-naturalness dimension featured 20 pas-

sages with supra-natural (i.e., magic) content, 20 control (magic-free), and 80 filler passages. For the Language dimension, participants read half of the passages in their native language (L1, German), and the other half in their second language (L2, English). Post-scan ratings for valence, arousal, fear and happiness were also collected from the participants of the fMRI study.

At the lexical and inter-lexical level, the implicit background processes of visual word recognition consist of visual-feature and orthographic processing, lexical access, semantic and phonological processing. While emotion-laden words show qualitatively similar potential to elicit emotion response as compared to other affective material, e.g., odors, facial expressions, and pictures (Citron, 2012; Kissler, Assadollahi, & Herbert, 2006), it was still unknown to what extent the emotion potential of single words, at the lexical and inter-lexical level, would contribute to the emotional impact of entire texts.

To this end, Chapter 2 investigates the potential of single words to induce emotional engagement when reading text passages taken from the Harry Potter book series. The author correlated lexical and inter-lexical affective variables with passage ratings and fMRI data, and distinguished differential influences of affective lexical, inter-lexical, and supra-lexical variables. Results showed significant correlations between affective lexical variables and passage ratings. Furthermore, affective lexical ratings correlated with activity in regions associated with emotion, situation model building, multi-modal semantic integration, and Theory of Mind. Specific effects of lexical valence were significant in the left amygdala, while effects of arousal-span (the dynamic range of the lexical arousal across words within a passage) were significant in the left amygdala and insula. However, no specific effect of passage ratings in emotion-associated regions was found. The results suggest that the emotion potential of texts can be predicted by lexical and inter-lexical affective variables.

During text comprehension, backgrounding elaborative inferences can be used to infer the emotional state of the protagonist of a story. *Affective empathy* (Walter, 2012) is an affective state elicited by the perceived, imagined, or inferred affective state of another, which is proposed to be involved in the phenomenon of immersion, a feeling of "getting lost in a book" (Nell, 1988). According to the *fiction feeling hypothesis* proposed by Jacobs (2011, 2014), narratives with emotional contents invite readers to be more empathic with the protagonists and thus engage the *affective empathy* network of the brain more likely than narratives with neutral contents. Thus, emotional contents should further facilitate the immersive reading experience. The core neural substrates of the *affective empathy* network consist of the anterior insula and the mid-cingulate cortex (Lamm, Decety, & Singer, 2011; Walter, 2012).

To investigate the neural correlates of the immersion reading experience, in Chapter 3 the author conducted a passage rating study of immersion, and compared the neural correlates of passage mean immersion ratings when reading fear-inducing versus neutral contents from Harry Potter books in the fMRI scanner. Immersion ratings were significantly higher for fear-inducing than for neutral passages, and activity in the mid-cingulate cortex correlated more strongly with immersion ratings of fear-inducing than neutral passages. The results suggest that emotional contents, especially negative ones, activate the affective empathy network and facilitate the immersive reading experience.

Chapter 4 investigates the turning point in which the implicit background process of situation model construction is interrupted by contents violating world-knowledge, which catch the reader's attention, turn the process of situation model updating explicit, and possibly create feelings of surprise or fascination. It is hypothesized that the violation of world-knowledge will activate the salience/emotion network (Lindquist et al., 2012; Seeley et al., 2007), which will recruit the fronto-parietal attention networks (Corbetta, Patel, & Shulman, 2008; Corbetta & Shulman, 2002; Pourtois, Schettino, & Vuilleumier, 2013). The author collected additional ratings on the dimensions of supra-naturalness, surprise, and reading pleasure for passages from Harry Potter books used as stimuli. Readers assigned passages in the supra-natural condition significantly higher scores on all three dimensions. Neural correlates of reading supra-natural vs. neutral contents include left amygdala, bilateral inferior frontal gyri, bilateral inferior parietal lobules, and left fusiform gyrus; the results are in line with previous studies and meta-analyses on world-knowledge integration (Hagoort, Hald, Bastiaansen, & Petersson, 2004; Menenti, Petersson, Scheeringa, & Hagoort, 2008), the salience network (Seeley et al., 2007), emotion processing (Costafreda, Brammer, David, & Fu, 2008; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012), and attention (Corbetta, Patel, & Shulman, 2008; Corbetta & Shulman, 2002; Pourtois, Schettino, & Vuilleumier, 2013).

Finally, the author investigated whether there is any quantitative or qualitative difference in emotion processing when reading in the first vs. a second language (L1 vs. L2) at the neuronal level. Hypothetical quantitative differences would involve the attenuated emotionality during L2 processing and therefore decreased sensitivity of amygdala to the emotion manipulation in the L2 text passages as compared to L1. In case of no quantitative difference, i.e., the intensity of emotionality in L2 is the same as in L1, quali-

tative differences could still arise, i.e., the spatially distributed activation pattern due to emotion processing could still be different in L1 vs. L2. The author performed factorial analyses on the post-scan ratings and fMRI data for Harry Potter passages that participants read in German (L1) and English (L2) to test for the interaction between bilingualism and emotion processing. Furthermore, multivariate pattern analyses (MVPA) were performed at different brain levels to test whether the general activation pattern differed between L1 and L2 processing, and whether the accuracy of the emotional categorical classification differed between L1 and L2. At the behavioral level, significant interactions between effects of emotion category and presented language were found for valence, fearfulness, and happiness ratings. They all showed stronger perceived emotionality in L1 than in L2. Furthermore, factorial fMRI analyses revealed stronger hemodynamic responses to happy passages than to neutral passages in bilateral amygdala and the left precentral cortex to be restricted to L1 reading. The author concluded: although reading in L2 cannot be described as generally emotionally distant, positive emotions seem to be processed more profoundly in the native language, and reading literature in L1 seems to also provide a more differentiated emotional experience.

Results of the present thesis supported the emotion potential of backgrounding elements such as word recognition (Chapter 2) and fiction feelings (Chapter 3), as well as the foregrounding element of world knowledge violation (Chapter 4) in the neurocognitive poetics model. Furthermore, the salience (Seeley et al., 2007), extended language (ELN; Ferstl, Neumann, Bogler, & von Cramon, 2008), and ToM (Mar, 2011) networks are extensively involved in both the backgrounding, as well as foregrounding aspects of emotion processing in literary reading. Although the salience network, especially the left amygdala, showed most consistent response for the affectivity of the literary materials, the results suggested that the proposed four hypotheses for neural networks for the affective response in literary reading are not mutually exclusive. Future studies on emotion processing in literary reading will benefit from this dissertation to develop more specific neuroscientific hypotheses on the causal relationships and interactions between different neural networks with more sophisticated methods, potentially applying such approaches to cross-linguistic/cultural studies.

Zusammenfassung

Emotionen tragen beutenden Anteil an der Schöpfung semantischer Sinneinheiten, welche gemeinhin als Wesensmerkmal menschlicher Sprache betrachtet werden können. Ebenso wie das Sprechen stellt auch das Lesen komplexe Anforderungen an höhere kognitive Funktionen, welche nur uns Menschen eigen sind. Dabei findet ungeachtet der Modalität eine Übertragung statt von Sinngestalten, Gefühlseindrücken, sprachlicher Nuancierung und zentraler Aussageabsicht des Autors (Oatley, 1995), welche im speziellen Falle des literarischen Lesens zweifelsohne auch von Gefühlen ästhetischer Wertschätzung seitens des Rezipienten begleitet sind (Brewer & Lichtenstein, 1982; Nell, 1988). Darüber hinaus ist das Wissen um emotionale Prozesse im Rahmen literarischen Lesens auch von zentraler Bedeutung hinsichtlich eines entwicklungspsychologischen Erkenntnisinteresses im Sinne förderlicher Einflüsse beispielsweise auf den Umfang des Wortschatzes (Cunningham & Stanovich, 1998), grammatische Kompetenz und Textverständnis (Cipielewski & Stanovich, 1992; Cox & Guthrie, 2001), sowie die Entwicklung positiver Einstellungen und sich daraus ergebender Motivation und Leistung (McKenna et al., 1995). Demgegenüber sind die neurokognitiven Grundlagen emotionaler Prozesse bei literarischem Lesen kaum erforscht. Die vorliegende Dissertation untersucht die Verarbeitungsmechanismen literarischen Lesens und ihre affektive Wirkung auf unterschiedlichen textlichen Strukturebenen von kleinen hin zu großen sprachlichen Einheiten. Als theoretischer Rahmen soll das Modell der neurokognitiven Poetik von Jacobs (2011, 2014) dienen. Dieses postuliert eine schnelle, automatische Route zur impliziten Verarbeitung von Textanteilen welche vornehmlich aus „Hintergrundelementen" bestehen. Eine langsamere Route dient dagegen der expliziten Verarbeitung von „Vordergrundelementen". Kernpunkte der vorliegenden Arbeit sind: 1) die lexikalische Ebene, auf welcher die Einzelwortverarbeitung zu verorten ist; 2) die inter-lexikalische Ebene, welche Abhänigkeiten von Wörtern unabhängig von Syntax beschreibt; 3) die supra-lexikalische Ebene, von welcher emotionaler Einfluss ausgeht über die bloße Repräsentationsebene einzelner Wörter hinaus. Es werden vier Hypothesen getestet bezüglich der neurokognitiven Korrelate der affektiven Wirkung literarischer Texte: 1) die Hypothese der neuralen Exaption (Anderson, 2010; Ponz et al., 2013), 2) die klassische psycholinguistische Hypothese, 3) Perspektivenübernahme und Identifikation (Oatley, 1995, 1999), und 4) Emotionen als „grounded" bzw. „embodied" (Niedenthal, 2007).

Es wurden ein fMRT-Experiment sowie diverse Verhaltensexperimente durchgeführt. Im Rahmen des fMRT-Experimentes wurden 120 Textpassagen aus der Buchreihe „Harry Potter" präsentiert. Diese waren faktoriell orthogonalisiert auf drei unterschiedlichen Dimensionen: Emotion, Übernatürlichkeit, und Sprache. Auf Ebene der Dimension Emotion wurden 40 furchtinduzierende, 40 freudeinduzierende sowie 40 neutrale Textpassagen präsentiert, welche sich darüber hinaus durch starke Varianz auf den affektiven Dimensionen Valenz und Arousal auszeichneten. Die Kategorisierung der Textabschnitte basierte auf einer vorab durchgeführten Studie, welche Ratings auf den Dimensionen Valenz, Arousal, Furcht und Freude erhob. Für die Dimension Übernatürlichkeit wurden je 20 Textabschnitte mit übernatürlichem Inhalt ausgewählt sowie 20 Kontrollitems, dazu 80 Fillerpassagen. Die Probanden lasen 50% der Textabschnitte in ihrer Muttersprache (L1, deutsch), die andere Hälfte dagegen in ihrer Zweitsprache (L2, englisch). Ratings im Anschluss an die fMRT-Untersuchung wurden analog zur Pilotstudie erhoben.

Auf der lexikalischen sowie inter-lexikalischen Ebene zählen zu den Hintergrundprozessen visueller Wortverarbeitung die Verarbeitung visueller Merkmale sowie orthografische Verarbeitung, lexikalischer Zugriff, semantische und phonologische Prozesse. Während emotionales Wortmaterial affektive Reaktionen in qualitativ vergleichbarer Weise auszulösen vermag wie beispielsweise Gerüche, Gesichtsausdrücke oder Bilder (Citron, 2012; Kissler et al., 2006), war das Ausmaß ihrer Wirkung auf höherer textlicher Ebene vorab nicht sinnvoll zu bestimmen. Kapitel zwei widmet sich der Wirkung von Wortmaterial auf die emotionale Involviertheit beim Lesen von Texten. Hierzu wurden Variablen auf lexikalischer und inter-lexikalischer Ebene korreliert mit Ratings der einzelnen Textpassagen und fMRT-Daten, weiter wurden differentielle Einflüsse auf affektive lexikalische, inter-lexikalische sowie supra-lexikalische Variablen kontrastiert. Es zeigten sich signifikante Zusammenhänge zwischen affektiven lexikalischen Variablen und Ratings der Textpassagen. Affektive lexikalische Ratings korrelierten darüber hinaus mit Aktivität in Regionen welche in der Literatur häufig mit Emotionen, der Bildungen von Situationsmodellen, multimodaler semantischer Integration und „Theory of Mind" in Zusammenhang gebracht werden. Effekte lexikalischer Valenz korrelierten mit Aktivität in der linken Amygdala, während Effekte der Spannweite von Arousal (dynamische Spannweite des lexikalischen Arousals innerhalb einer Textpassage) signifikant mit Aktivität in der rechten Amygdala und Insula korrelierten. Spezifische Effekte bezüglich des Ratings von Textpassagen in emotionsrelevanten Hirnarealen fanden sich nicht. Die Ergebnisse legen nahe, dass sich der emotionale Gehalt eines Textes durch lexikalische und interlexikalische Variablen vorhersagen lässt.

Im Rahmen von Textverständnis lassen sich Inferenzen basierend auf Hintergrundelementen nutzen, um weiterreichende Schlussfolgerungen bezüglich der emotionalen Verfasstheit des Protagonisten zu ziehen. Affektive Empathie (Walter, 2012) bezeichnet einen affektiven Zustand welcher herbeigeführt wird durch den wahrgenommenen, vorgestellten oder inferierten affektiven Zustand anderer, welcher in engem Zusammenhang steht mit dem Phänomen der Immersion, einem Gefühl des „sich Verlierens in einem Buch“ (Nell, 1988). Der Hypothese der fiktionalen Gefühle entsprechend (Jacobs, 2011, 2014) verleiten Narrationen mit höherem emotionalen Gehalt den Leser eher zur empathischen Anteilnahme mit dem Protagonisten und aktivieren folglich eher neuronale Netzwerke im Zusammenhang mit affektiver Empathie als vergleichsweise neutrale Textinhalte, was wiederum zu gesteigerter immersiver Leseerfahrung führt. Zentrale Anteile des Netzwerks der affektiven Empathie bilden die anteriore Insula und der mittlere zinguläre Kortex (Lamm et al., 2011). Kapitel 3 behandelt die Durchführung einer Ratingstudie zu Immersion und den anschließenden Vergleich neuronaler Korrelate bezüglich gemittelter Ratings von Immersion beim Lesen von furchtinduzierenden gegenüber neutralen Inhalten. Ratings von Immersion waren signifikant höher für furchtinduzierende gegenüber neutralen Textpassagen, ferner korrelierte die Aktivität im mittleren zingulären Kortex stärker mit Ratings von Immersion im Zusammenhang mit furchtinduzierenden Textpassagen als dies für neutrale Texte der Fall war. Die Ergebnisse legen nahe, dass der emotionale Gehalt von Texten, insbesondere negative Inhalte, das Netzwerk affektiver Empathie anregen und zu gesteigerter immersiver Leseerfahrung führen.

Kapitel 4 setzt sich mit Gefühlen von Überraschung oder Faszination auseinander. Diese resultieren, wenn der implizite Aufbau eines Situationsmodels im Rahmen des Hintergrundprozesses unterbrochen wird, beispielsweise durch eine Verletzung von Erwartungen, welche sich aus dem Weltwissen des Lesers ergeben. In der Folge wird der Prozess expliziert und erfordert mehr Aufmerksamkeit. In diesem Zusammenhang wird die Aktivierung eines Salienz- bzw. Emotionsnetzwerkes postuliert (Lindquist et al., 2012; Seeley et al., 2007), welches ferner Anteile des fronto-parietalen Aufmerksamkeitsnetzwerkes einbezieht (Corbetta et al., 2008; Corbetta & Shulman, 2002; Pourtois et al., 2013). Diesbezüglich wurden zusätzliche Ratings für die Dimensionen Übernatürlichkeit, Überraschung und Lesevergnügen erhoben. Textpassagen in der Bedingung „Übernatürlichkeit“ zeichneten sich durch signifikant höhere Ratings auf allen drei Bereichen aus.

Neuronale Korrelate eines Effektes „übernatürlicher“ Textinhalte beinhalten die linke Amygdala, bilaterale inferiore frontale Gyri, bilaterale inferiore parietale Lobuli sowie den linken Gyrus fusiformis in Übereinstimmung mit Vorgängerstudien und Metaanalysen zur Integration von Weltwissen (Hagoort et al., 2004; Menenti et al., 2008), dem Salienznetzwerk (Seeley et al., 2007), emotionaler Verarbeitung (Costafreda et al., 2008; Lindquist et al., 2012), und Aufmerksamkeit (Corbetta et al., 2008; Corbetta & Shulman, 2002; Pourtois et al., 2013).

Schließlich wurden quantitative wie qualitative Unterschiede emotionaler Verarbeitung bezüglich des Lesens in der Erst- bzw. Zweitsprache auf neuronaler Ebene untersucht. Quantitative Unterschiede beziehen sich auf eine Abschwächung emotionaler Effekte im Rahmen der Verarbeitung in der Zweitsprache, welche in Verminderter Sensitivität der Amygdala resultieren sollte. Qualitative Unterschiede bezeichnen eine Vergleichbare Intensität in der Verarbeitung affektiver Information in der Erst- und Zweitsprache bei möglicherweise räumlich unterschielichen Aktivitätsmustern. Diesbezüglich wurde eine Varianzanalyse auf Basis der nachträglich erhobenen Ratings sowie der fMRT-Daten durchgeführt. Des Weiteren wurde eine multivariate Musteranalyse (MVPA) durchgeführt im Falle qualitativ unterschiedlicher Aktivitätsmuster zwischen Erst- und Zweitsprache sowie für den Fall, dass die Vergleichbarkeit einer kategorialen Klassifikation des emotionalen Gehaltes über Sprachen hinweg nicht gegeben ist. Auf behavioraler Ebene fanden sich signifikante Interaktionen zwischen Effekten von Emotion und präsentierter Sprache für Ratings von Valenz, Furcht und Freude. In jedem Fall ließ sich eine stärker wahrgenommene Emotionalität in der Erstsprache gegenüber der Zweitsprache feststellen. Eine Varianzanalyse der fMRT-Daten zeigte eine stärkere hemodynamische Response bezüglich Textpassagen mit höheren Ratings auf der Dimension Freude gegenüber neutralen Inhalten in bilateraler Amygdala und linkem präzentralen Kortex, welche auf die Erstsprache beschränkt blieben. Auch wenn sich hieraus keineswegs das Bild einer durchweg emotional distanzierten Leseerfahrung bei Rezeption in der Zweitsprache ergibt, so lässt sich dennoch schlussfolgern, dass insbesondere positive Emotionen stärkere Effekte in der Erstsprache herbeiführen und dies darüber hinaus zu einer differenzierteren emotionalen Erfahrung führt.

Abschließend soll festgestellt werden, dass sowohl Hintergrundprozesse wie Vordergrundprozesse wie im Model neurokognitiver Poetik postuliert (Jacobs, 2011, 2014) signifikant zur emotionalen Leseerfahrung beitragen. An beiden Prozessen sind maßgeblich Netzwerke der Salienz (Seeley et al., 2007), des ELN (Ferstl et al., 2008), sowie ToM

(Mar, 2011) beteiligt. Eine bemerkenswert hohe Konsistenz eines Antwortmusters hinsichtlich des affektiven Gehaltes des literarischen Materials ließ besonders für das Salienznetzwerk, insbesondere die linke Amygdala feststellen. Dennoch legen die vorliegenden Resultate keineswegs nahe, dass sich die zuvor postulierten vier Hypothesen gegenseitig ausschließen. Für zukünftige Studien zur Untersuchung affektiver Information auf Verarbeitungsprozesse im Rahmen literarischen Lesens legt diese Dissertation die Grundlage für eine detailliertere neurowissenschaftliche Hypothesenbildung, welche maßgeblich der Anwendung elaborierterer Methoden auf die Untersuchung kausaler Abhängigkeiten und Interaktionen differenzierter neuronaler Korrelate bzw. Netzwerke beispielsweise auch in sprachübergreifenden und kulturvergleichenden Ansätzen dienen soll.

Übersetzung: David Schmidtke

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1. Introduction

Emotion originates from the innate responses of the organism toward deviations of inner and outer environment (Damasio & Carvalho, 2013). For the sake of survival, those responses modulate the organism's behavior, decision-making, and cognitive recourses of attention, learning and memory (Dolan, 2002; LeDoux, 2012; Panksepp, 1998). For hominids, emotions are important semantic features, and have a two-fold communicative function, both externally amongst members of the species, and internally within the brain (Johnson-Laird & Oatley, 1989). Reading is a higher-order activity exclusive for human beings. During reading, sense, feeling, tone, and the intention of the writer is transmitted via words to the mind of the reader (Oatley, 1995). Furthermore, literary reading of novels or poems brings pleasures, including feelings of suspense, vicarious joy (or fear), or beauty (Brewer & Lichtenstein, 1982; Nell, 1988). Pleasure is intimately linked to emotional and reward processing in the brain, yet the neurocognitive processes involved in reading (Price, 2012) are far more complicated than fundamental activities like food intake, sex, or even social interaction (Berridge & Kringelbach, 2008). However, the underlying processes that bridge the cognition – emotion gap (Dolan, 2002) are still hardly understood (Kringelbach, Vuust, & Geake, 2008; Schrott & Jacobs, 2011; Wolf, 2007).

The knowledge about emotion processing in literary reading is essential, especially for developmental and educational purposes, because 1) while language processing abilities are essential for reading pleasure, reading enjoyment also benefits children's capability in vocabulary (Cunningham & Stanovich, 1998), grammar, text comprehension (Cipielewski & Stanovich, 1992; Cox & Guthrie, 2001), and further positive attitude and achievement in reading (McKenna et al., 1995); 2) children's motivation to read is highly relevant to the emotional impact of reading, e.g., the enjoyment, the calming effect, and the "transport" (similar to immersion, which will be discussed in Chapter 3) of the reader into the world of the story. Therefore, this dissertation aims to investigate mechanisms through which the emotion processing during literary reading brings about enjoyment at different levels of textual structure from smaller to larger units. I will focus on different levels of processing in the following sequence: 1) the lexical level, at which single words are processed; 2) the inter-lexical level, at which the specific relationship between words independently of syntax structure comes into play; 3) the supra-lexical level, at which the emotional impact originates beyond the impact of the representation of words. While the sublexical level, at which the phonological processing and its symbolic connotations elicit salience and emotion, is also very important, relevant research is still under progress, and thus will not be covered here.

1.1 Biological significance and origins of emotion

Emotion possesses different meanings among different investigators. According to Kagan (2010), emotion contains four distinct phases: 1) the brain state created by an incentive; 2) the agent's detection or perception of a change in bodily activity; 3) the semantic appraisal of a change in bodily feeling; and 4) observed changes in facial expression, muscle tension, autonomic reaction, concentration of a molecule, or goal-directed action. Similarly, Panksepp (2005) conceptualized emotional feelings into 1) first-order phenomenology, which reflects raw sensory/perceptual feelings and types of internal motional/motivational experiences; 2) second-order awareness, which reflects the capacity to have thoughts about experiences, especially about how external events relate to internal events; and 3) tertiary consciousness including thoughts about thoughts, awareness of awareness, which requires human-typical linguistic–symbolic transformation.

The primary phenomenology has been much discussed. According to Damasio and Carvalho (2013), the CNS monitors the interior environment with the interoceptive system which could be experienced as "feelings", and triggers the innate action program "drives". The action program contains a set of actions including changes in viscera and internal milieu (heart rate, breath, endocrine), striated muscles (facial expressions and running), and cognitions (attention and preference). Drives are aimed at satisfying basic instinctual needs and include hunger, thirst, libido, exploration and play, care of progeny and attachment to mates. The external environment is monitored via the exteroceptive senses (smell, taste, touch, hearing and sight), which trigger another action program "emotions". Both drives and emotions facilitate homeostatis including the governance of metabolism and the maintenance of somatic integrity via self-repair and defense. Numerous brain regions along the neuraxis in the brain stem (e.g., nucleus tractus solitarius, periaqueductal grey, and hypothalamus), in the subcortical grey matter (e.g., amygdala, nucleus accumbens, and ventral pallidum), and in the cerebral cortex (e.g., insula, anterior cingulate and somatosensory cortices) are all involved in generating homeostatic actions. They all constitute a system of sensing and mapping body states and generating feelings.

On the other hand, LeDoux (2012) identified distinct emotional/motivational circuits innately wired into the brain and mediating functions that contribute to survival and well-being of the organism. Examples of the survival circuits include defense, reproduction, thermoregulation, fluid balance, and energy/nutritional regulation. In the case of defense, detected predator odors trigger a chain of processing via the vomero-nasal olfactory system, the medial amygdala, the hypothalamus, the dorsal PAG, and motor control areas, which direct the expression of behavioral responses. The survival functions/circuits are closely intertwined. Depending on the deviation of homeostatis, some functions dominate while others are actively suppressed at a certain point. The survival circuits accompany automatic, unconscious appraisal mechanisms for the computation of stimulus significance. The activation of survival circuits and motivational systems (the dopaminergic circuit, especially nucleus accumbens) leads to arousal responses in the CNS and to the potential expression of goal-directed behaviors. Meanwhile, the organism becomes especially attentive to survival function relevant sensory, learning, and memory processes, which is called global organismic states.

Furthermore, Panksepp (1998, 2005) proposed discrete intrinsic psychobehavioral control systems of core emotional affects including SEEKING, RAGE, FEAR, LUST, CARE, PANIC, and PLAY. The SEEKING system responds to homeostatic imbalances and environmental incentives, which contains the dopaminergic circuit around lateral hypothalamus including ventral tegmental area and nucleus accumbens. The RAGE system is triggered by irritations and frustrations that arise from restricted freedom of action or access to resources, which leads to anger and aggression. The RAGE circuits range from medial amygdala, hypothalamus, and the PAG. The perception or anticipation of danger activates the FEAR circuit between the central amygdala and the PAG, which prompts animals to hide (freeze) or flee. The LUST system located in the hypothalamus consists of the arginine-vasopressin (AVP) circuits in males and the oxytocin circuit in females. On the other hand, these two circuits are also part of the CARE system, which facilitates nurturance behaviors and social bonding. The PANIC system is triggered by separation distress and social isolation. Studies of the distress vocalization in rats indicated that the PANIC system arise from the PAG, the dorsal thalamus, the ventral septal and preoptic area of hypothalamus, and the bed nucleus of stria terminalis. In some higher species, it also involves ACC and amygdala. The circuit of endogenous opioids (corticotrophin releasing factor and β-endorphin systems) and oxytocin suppresses the PANIC system. The PLAY system is linked to somatosensory information processing within the midbrain, thalamus and somatosensory cortex, although decortication does not eliminate play motivation (Panksepp, Normansell, Cox, & Siviy, 1994).

In terms of emotional awareness and emotional consciousness, Craig (2002, 2003, 2009) has proposed that anterior insula and dorsal ACC generate meta-representations of "global emotional moments", because they are interconnected by *von Economo* neurons, which enable fast and highly integrated representations of emotional moments and behaviors.

Concerning the neural substrates of emotional phenomenology and consciousness in human beings, Seeley et al. (2007) has identified the intrinsically connected "salience network" anchored to the activity in orbitofrontal insular and dorsal ACC in response to pain, uncertainty, and other threats to homeostasis. Besides orbitofrontal insula and dorsal ACC, major neural substrates of this network include the anterior insula, pre-SMA and superior temporal pole on the cortical level. On the subcortical level the network comprises amygdala, ventral striatopallidum, dorsomedial thalamus, hypothalamus, PAG, and substantia nigra/ventral tegmental area (Fig. 1.1).

On the level of linguistic–symbolic transformation, Shanahan (2008) proposed that the emotional feeling often associates with an irregular but recurrent experience associated with alarm. Thus, the emotional experience eventually becomes reified, and the reification provides the basis for symbolization. According to Lange (1972), the emotional experiences which have been the subject of self-monitoring become associated with images in the unconscious. The images register the stimuli on the organism's perceptual field and have picked up short-term emotional values. In the process of symbolization, they begin to recur, take on lasting emotional value, and become symbols, which are enduring, expressive renderings of the reifications of the organism's subjective experience. Furthermore, Lange suggested that dance is the transition of hominids from symbolizing to language. Dances originated from gestures approximating actions early hominids made to dispel the source of their awe and anxiety in real life. Repetition of the gestures formalized them and allowed them to take on common meaning for the group, such as systematic expression of the reified emotion. Vocalizations made in the dance would have become associated with the gestural symbolic system, and eventually have freed one's hands for other things. It would have led to the use of vocalizations – speech – as the preferred form of linguistic communication (Shanahan, 2008).

Panksepp (1998, 2005) proposed and identified discrete affective systems in neuronal circuits. Similarly, by investigating cross-cultural emotion recognition using facial expressions Ekman (1992) classified emotion as a set of discrete "basic" emotions including happy, surprise, sad, angry, disgust, and fear. Johnson-Laird and Oatley (1989) consider emotions as functions of communications. They proposed that the semantic field is based on five basic emotional modes (happiness, sadness, fear, anger, and disgust), and words that refer to them have no internal semantic structure, which means that the modes are primitive and unanalyzable.

Alternatively, some psychologists take the dimensional perspective, pioneered by Wundt (1874) who attempted to develop a structural description of subjective feeling as it is accessible through introspection. He proposed a three-dimensional space formed by the dimensions of valence (positive–negative), arousal (calm–excited), and tension (tense–relaxed) (Scherer, 2005). While modern dimensional theorists consistently used the dimensions of "valence" and "arousal" (Lang, Bradley, & Cuthbert, 1990; Russell, 1980), the identification of a third dimension has been inconsistent, e.g. "tension" by Wundt (1874), "attention-rejection" by Schlosberg (1954), and "potency" by Osgood, Suci, and Tannenbaum (1957). Russell (1980, 2003) defined "core affect" as a neurophysiological state that is consciously accessible as a simple, non-reflective feeling that is an integral blend of hedonic (pleasure–displeasure) and arousal (sleepy–activated) values.

The present dissertation follows the two-dimensional view with valence and arousal of Russell (1980, 2003) through out all studies. On the other hand, the categorical view of basic discrete emotions is taken into consideration along with the concepts of valence of arousal as the theoretical background in individual studies e.g., fear (Study 2 & 4), surprise (Study 3), and happy (Study 4).

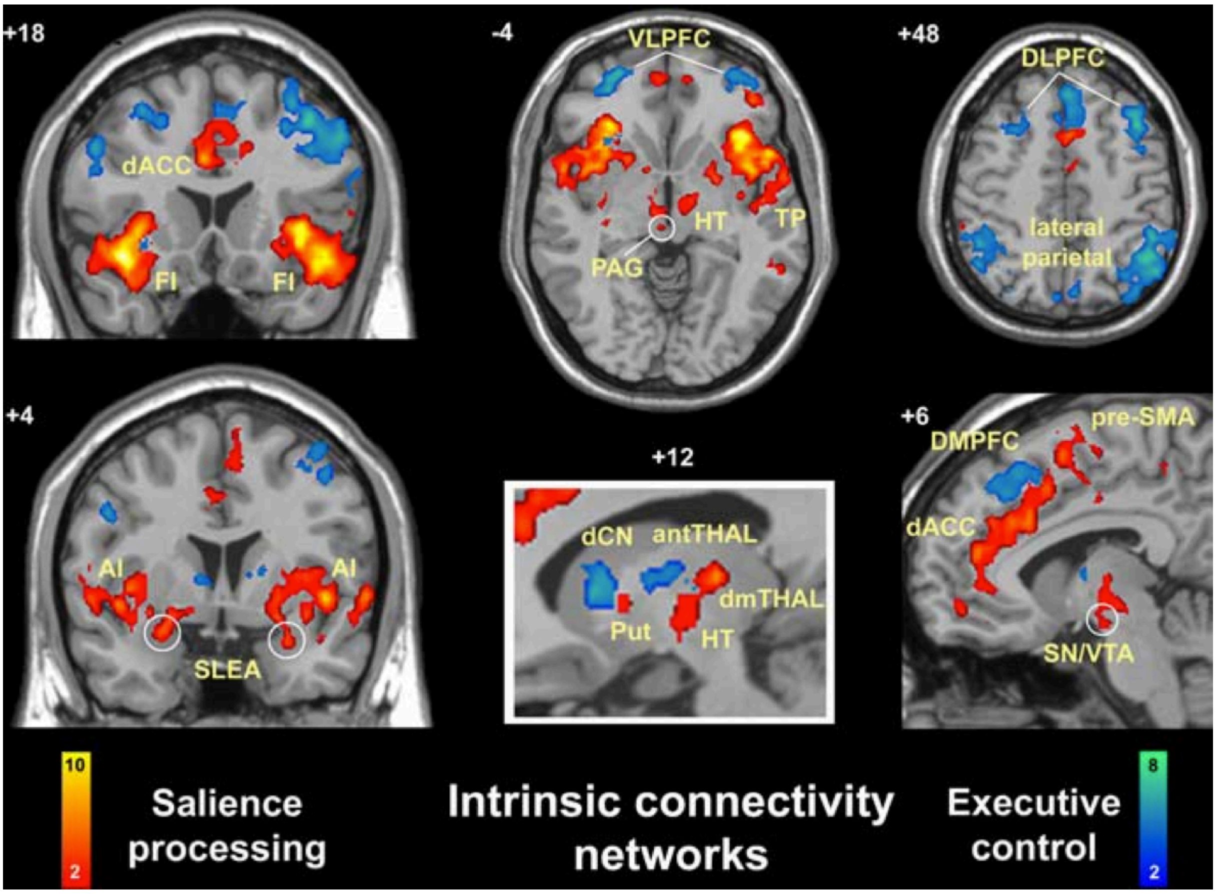

Fig. 1.1. The "salience network" (red) and "executive-control network" (blue) identified by Seeley et al. (2007). Taken from Seeley et al. (2007), Figure 2. Abbreviations: AI, Anterior insula; antTHAL, anterior thalamus; dCN, dorsal caudate nucleus; dmTHAL, dorsomedial thalamus; DMPFC, dorsomedial prefrontal cortex; HT, hypothalamus; PAG, periaqueductal gray; Put, putamen; SLEA, sublenticular extended amygdala; SN/VTA, substantia nigra/ ventral tegmental area; TP, temporal pole; VLPFC, ventrolateral prefrontal cortex.

1.2 Neurocognitive aspects of language processing in reading

Reading comprises complex cognitive processes (Price, 2012). In order to bridge the gap of emotion-cognition coupling in reading at the neuronal level, the neuroanatomy of language processing underlying reading will be introduced. First, the primary visual cortex receives visual input. Following processes consist of the visual feature and orthographic processing, lexicon access, semantic and phonologic processing. Current functional neuroimaging evidence supports the connectionists' view that the processes of visual feature extraction takes place in the occipital pole, orthography processes in the fusiform gyrus, phonology processes in the posterior temporal cortex and IFG, and semantics processes in the IFG, aTL, and TPJ. These processes are neither isolated nor sequential, but mutually interactive (Fig. 1.2; Carreiras, Armstrong, Perea, & Frost, 2014).

During word recognition, an implicit grapheme to phoneme conversion starts the sublexical phonological processing. By recording cortical activity directly using high-density multielectrode arrays, it has been shown that neurons around each electrode showed phonetic feature selectivity (plosive, fricative, and sonorant) due to their tuning to specific spectrotemporal cues (Mesgarani, Cheung, Johnson, & Chang, 2014). Furthermore, the spatially distributed activation pattern for speech sounds along middle and posterior STG is categorically organized (Chang et al., 2010). On the other hand, the IFG serves as an integrative site for high-level linguistic properties like phonology and semantics and provides feedback connections to constrain the orthographical representations of the fusiform gyrus (Carreiras et al., 2014; Woodhead et al., 2014).

Beyond the single word level, grammatical processes take place to bring isolated words together into a coherent comprehension of phrases, sentences, or text paragraphs (Jackendoff, 2007). With a unit size which is larger than single words, the word combinations, the syntactic structures, the accompanied temporal (tense), logical (negation), directional, intentional or judgemental (subjunctive mood) information together with our learned world knowledge (Hagoort et al., 2004) bring the level of language comprehension far beyond the comprehension of isolated single words. Among the grammatical processes, the syntax processing relies on at least three fronto-temporal networks (van der Lely & Pinker, 2014): 1) the dorsal arcuate fasciculus connecting BA 44 and posterior STG for the hierarchical phrase structure and syntactically complex sentences, 2) the ventral uncinate fasciculus connecting frontal operculum and the aTL (anterior STG) for the local phrase structure, 3) the ventral extreme capsule fiber system connecting BA 45 and the posterior STG and superior STS for the lexical and phrasal semantics. The morphological processing important for the recognition and computation of inflectional forms is mediated by the arcuate fasciculus connecting BA 44, 45 and 47 with the posterior STS for the rule-generated regular inflection.

Regarding text comprehension, a recent neurocognitive poetics model of literary reading (Jacobs, 2011, 2014) proposed that literary reading can be viewed as a process of constructive content simulation (Mar & Oatley, 2008), closely linked to perspective taking and relational inferences associated at the neural level with the activation of the extended language network (ELN, Ferstl et al., 2008), the Theory of Mind (ToM) network (Mason & Just, 2009), brain regions associated with affective or mood empathy (Altmann, Bohrn, Lubrich, Menninghaus, & Jacobs, 2012, 2014; Frith & Frith, 2003; Lüdtke, Meyer-Sickendiek, & Jacobs, 2014; Mar & Oatley, 2008), and with reward and aesthetic pleasure (Bohrn, Altmann, Lubrich, Menninghaus, & Jacobs, 2013). These processes converge to fulfill the goal of literary reading: i.e., meaning construction and the closure of *meaning gestalts* which depends on many factors, including the affective meaning of single words and passages (Iser, 1976; Jacobs, 2014).

The cognitive aspect of discourse comprehension involves three different processing steps (Schmalhofer & Glavanov, 1986; Van Dijk & Kintsch, 1983): 1) the construction of the *surface structure* of a text, which is a mental representation of the exact text read; 2) a *text-base representation*, which contains idea units explicitly stated in the text, including bridging inferences that help connecting consecutive clauses; and 3) a *situation model* of the text, in which the current linguistic input (i.e., the linguistic meaning of the sentence or paragraph being read) is integrated with both general world knowledge and the prior discourse context (Graesser, Millis, & Zwaan, 1997; Zwaan & Radvansky, 1998).

In a review based on a meta-analysis (Ferstl et al., 2008), Ferstl (2010) summarized key neural substrates for the literary language. For the text-based comprehension, inferential processes are required for the coherence and cohesion of text comprehension. Simple and unambiguous inferential processes involve grammatical (morpho-syntactic) processing (Hammer, Goebel, Schwarzbach, Munte, & Jansma, 2007) and the access of lexico-semantic and background knowledge. On the other hand, ambiguous, incomplete, or inconsistent referential processes require more complicated inferential processes. Ferstl and von Cramon (2001) have shown that dmPFC and the PCC/precuneus were more active during successful inferencing compared to the comprehension of unrelated sentences. The involvement of dmPFC in the inferential processing is evident in many other studies (Friese, Rutschmann, Raabe, & Schmalhofer, 2008; Kuperberg, Lakshmanan, Caplan, & Holcomb, 2006; Mason & Just, 2009; Sieborger, Ferstl, & von Cramon, 2007) and is significant in the meta-analysis by Ferstl et al. (2008). DMPFC has also been associated with the processing of metaphor (Shibata, Abe, Terao, & Miyamoto, 2007), idiom (Lauro, Tettamanti, Cappa, & Papagno, 2008), sarcasm (Uchiyama et al., 2006), and irony (Wakusawa et al., 2007) comprehension, in which inferential processes also play an important role.

The level of situational model processing generally engages the ELN (Xu, Kemeny, Park, Frattali, & Braun, 2005). The posterior parietal regions seem to be particular important for the setting up of the initial situational model (Yarkoni, Speer, & Zacks, 2008). As for the situation model updating, information of locational shift recruits right posterior STG, the PCC and dorsal precuneus (Speer, Zacks, & Reynolds, 2007; Whitney et al., 2009); by using the inconsistency paradigm, studies have shown that the situation model violation of inconsistency generally activates aTL, which is important for the encoding of text information into content units (Hasson, Nusbaum, & Small, 2007; Stowe, Haverkort, & Zwarts, 2005); temporal inconsistencies activate the fronto-parietal network; emotional inconsistencies elicited activation in the vmPFC and the amygdala (Ferstl, Rinck, & von Cramon, 2005), while spatial inconsistency engages bilateral PHC (Ferstl & von Cramon, 2007).

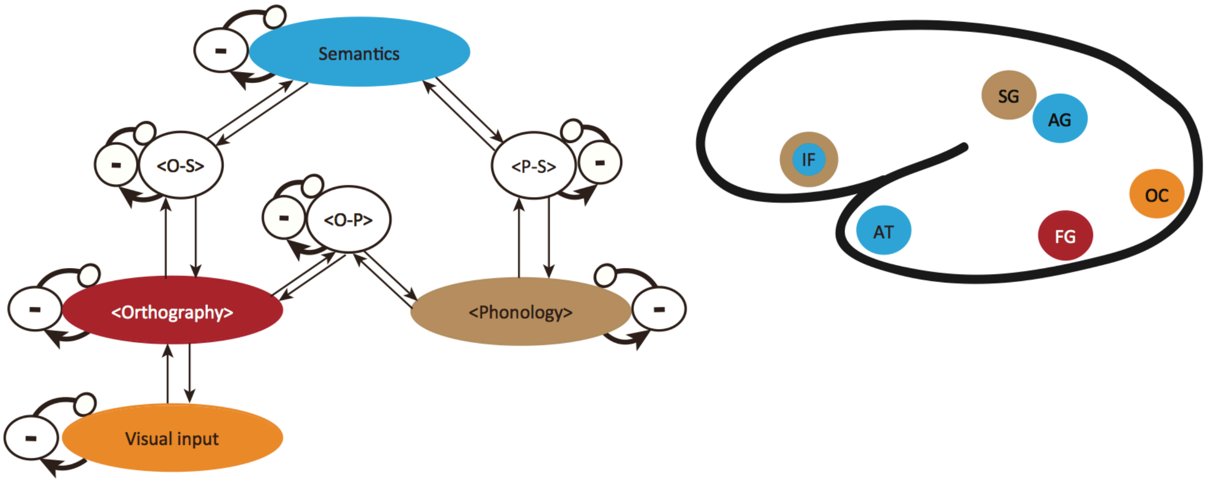

Fig. 1.2. The connectionists' view of visual word recognition (left) and associated brain regions (right). From Carreiras et al. (2014), Figure 2 (D) and (E). Abbreviations: IF, inferior frontal cortex; SG, supramarginal gyrus; AG, angular gyrus; AT, anterior temporal cortex; FG, fusiform gyrus (includes visual word form area, VWFA); OC, occipital cortex.

1.3 Affective aspects of language processing in reading

While there is now a growing literature in cognitive neuroscience on affective processes during single word recognition (Citron, 2012; Kissler et al., 2006), standard models of word recognition (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Grainger & Jacobs, 1996), reading (e.g., Just & Carpenter, 1980), sentence (e.g., Friederici, 2002; Taraban & McClelland, 1988), and text processing (e.g., Ferstl et al., 2008; Kintsch, 1988) focus on "cold" cognitive processes and remain silent with regard to "hot" affective and emotional mechanisms (but see Ferstl et al., 2005; Jacobs, 2014; Wallentin et al., 2011, for exceptions). There is, however, an abundant literature on such processes in journals and books featuring poetics (Bortolussi & Dixon, 2003; Brewer & Lichtenstein, 1982; Iser, 1976; Kneepkens & Zwaan, 1995; Mar, 2011; Miall & Kuiken, 1994, 2002; Oatley, 1995). The neurocognitive poetics model of literary reading (Fig. 1.3; Jacobs, 2011, 2014) has attempted to link the findings of such studies with neuropsychological data and results from linguistics and aesthetics, formulating hypotheses about which text elements evoke which cognitive, emotional, or aesthetic processes, and operationalizing these at the three relevant levels, i.e. neuronal, cognitive-affective, and behavioral (Jacobs, 2011, 2014). Jacobs proposed a dual-route processing of literary texts: a fast, automatic route for implicit processing texts which mainly consist of "background" elements, and a slower route for explicit processing of "foregrounded" text elements. Backgrounding represents the repertoire of familiar literary patterns and recurrent literary themes and allusions to familiar social and historical contexts that are necessary for daily communication and situation model building in literary reading, or in the words of Mukařovský (1964 [1932]), the norm of the standard language and the traditional aesthetic canon. Background elements are processed less consciously in an automatized way (Jacobs, 2011; Miall & Kuiken, 1994). Foregrounding elements (e.g., alliteration, rhyme, inversion, ellipsis, metaphor, or irony) lead to defamiliarization effects in which the stylish variation in literature violates the constructed situation model, catches the attention of the readers, and brings about the novelty and emotional richness associated with the aesthetic pleasure often characteristic of literary reading (Miall & Kuiken, 1994; Van Peer, 1986, 2007; Van Peer & Hakemulder, 2006). The present dissertation follows the structure of the neurocognitive poetics model of literary reading, and poses relevant research questions to test key assumptions of the model.

Based on the building blocks of our understanding about emotion theory and literary text comprehension, the introduction will continue with the background information of emotion processing in literary reading, which will also be further detailed in the introductory section of each chapter separately.

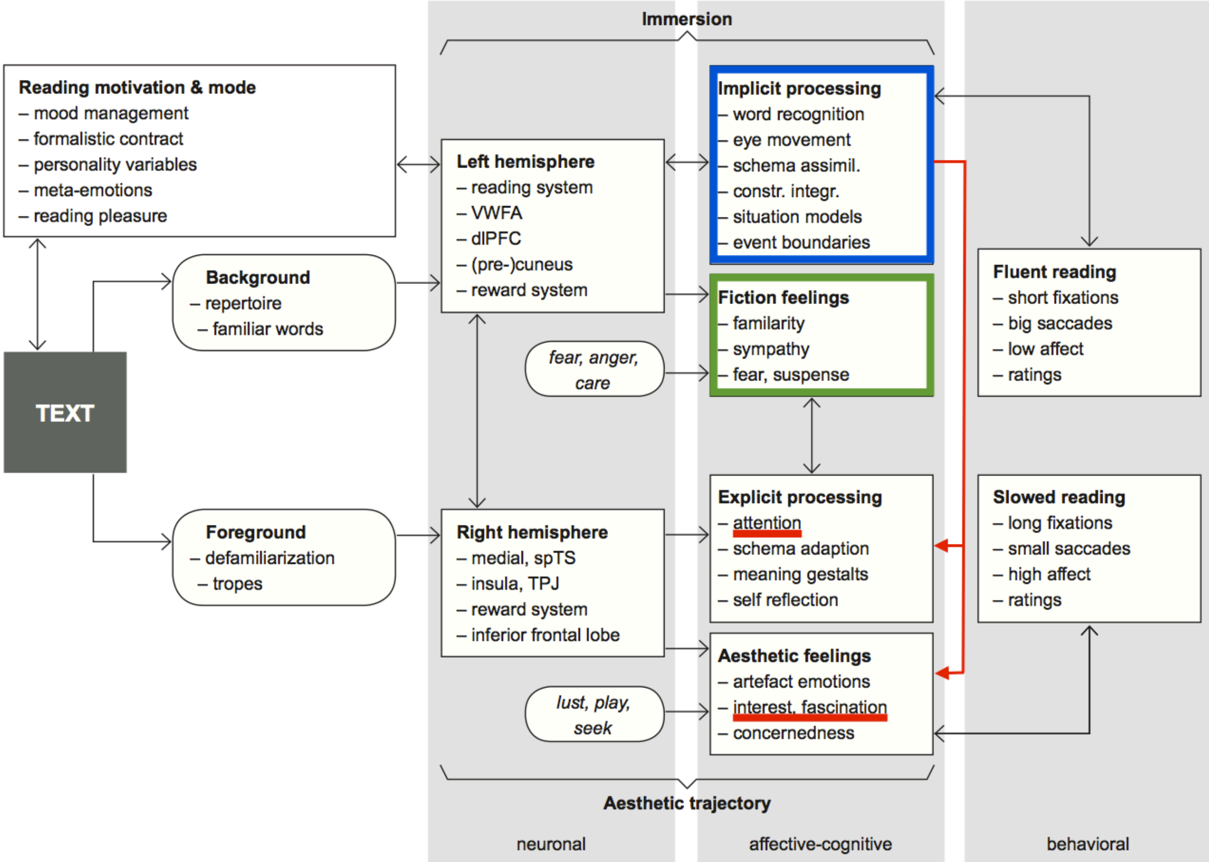

Fig. 1.3. The simplified neurocognitive poetics model of literary reading by Jacobs (2011, 2014). Taken from Figure 7.2 of Jacobs (2014). Blue: focus of Study 1/Chapter 2; Green: focus of Study 2/Chapter 3; Red: focus of Study 3/Chapter 4.

1.3.1 Affective processing of words in reading

The establishment of emotion word databases has enabled researchers creating highly controlled word-based materials (Graf, Nagler, & Jacobs, 2005) for a wide range of experiments dealing with the emotional processing of words. Such databases are usually established with a two-dimensional approach by including valence and arousal ratings (Osgood, 1969; Osgood et al., 1957) together with other lexical and semantic properties like ratings of imageability and concreteness. Examples include *Dictionary of Affect in Language* (DoA; Whissell & Dewson, 1986), *Affective Norms for English Words* (ANEW; Bradley & Lang, 1999), *Berlin Affective Word List* (BAWL; Võ et al., 2009; Võ, Jacobs, & Conrad, 2006), and a recent database of 13,195 English lemmas (Warriner, Kuperman, & Brysbaert, 2013).

Research on emotion-laden word processing has been extensively performed at the three relevant psychological levels: the experiential (e.g., subjective ratings, self-reports; Võ et al., 2009; Võ et al., 2006), the behavioral (e.g., response times, oculo- and pupillometric responses; Briesemeister, Kuchinke, & Jacobs, 2011a, 2011b; Võ et al., 2006; Võ et al., 2008), and the neuronal level, using both electrophysiological (e.g., Briesemeister, Kuchinke, & Jacobs, 2014; Conrad, Recio, & Jacobs, 2011; Fischler & Bradley, 2006; Hofmann, Kuchinke, Tamm, Võ, & Jacobs, 2009; Recio, Conrad, Hansen, & Jacobs, 2014) and functional neuroimaging methods (e.g., Citron, Gray, Critchley, Weekes, & Ferstl, 2014; Kuchinke et al., 2005). Two pioneer fMRI studies will be highlighted below.

In an fMRI study on visual emotion word processing, Kuchinke et al. (2005) presented single emotional and neutral words controlled for several lexical and semantic word properties in a visual lexical decision task. They reported enhanced activation of the left OFC and bilateral IFG in response to emotional words compared to neutral words, during implicit processing of their emotional content.

Using a parametric design, Lewis, Critchley, Rotshtein, and Dolan (2007) presented participants with positive and negative words taken from ANEW (Bradley & Lang, 1999) that varied systematically along the dimension of arousal, during a self-referential task, indicating whether each word could be used to describe themselves. They showed activation of the OFC and anterior insula to be positively correlated with the valence intensity of positive words; activation of the OFC and subgenual ACC to be positively correlated with the valence intensity of negative words; activation of the OFC, subgenual and pregenual ACC fit into the U-shaped model of valence; activation of the left amygdala, anterior insula, right pallidum, and right ventral striatum correlated with arousal. This study suggested that apart from arousal, the U-shaped model for valence also codes for a generalized form of "salience," thus aiding in the direction of attention toward behaviorally important goals (Cunningham, Raye, & Johnson, 2004; Winston, O'Doherty, & Dolan, 2003).

In comparison with other types of stimuli employed to investigate emotion processing, including odors, facial expressions, and pictures, words show qualitatively similar emotional effects like other affective material. However, under most circumstances, non-verbal stimuli are stronger in their effects, apparently because of their biological preparedness to elicit emotional reactions (Citron, 2012; Kissler et al., 2006).

Regarding the relevance of the emotion processing of single words in literary reading, Bestgen (1994) computed the correlations between the rated valences of the sentences at the textual, the sentential, and the lexical level (by calculating mean valence values of words composing the sentences) in four short stories. The linear correlations between rated valence at the textual and lexical level, and between textual and sentential level were high and significant (between .55 and .84, depending on the text). It demonstrated that a text's emotion potential can be estimated as a function of affective values of the constituting words. Study 1 in Chapter 2 will further delineate the specific contribution of the lexical and inter-lexical level variables to the holistic emotion potential of narrative texts in the background processing of literary reading.

1.3.2 Affective processing in reading at the inter-lexical level

In the neurocognitive poetics model by Jacobs (2011, 2014), the importance of the emotion potential of words in literary reading was emphasized not only at the level of single words, but also at the level of the synergy of words comprising a text, the inter-lexical level. Jacobs proposed that besides the lexical level, the face value of the valence and arousal of single words, and the supra-lexical level, where figurativeness and context variables come into play, the emotion potential of a text might be elicited by the dynamic changes or contrasts in the affective reactions a reader experiences when reading the text word by word.

One can operationalize this novel and heuristic concept by means of the "span" measure, i.e., the difference between the maximal and the minimal word valence/arousal values in a text segment, and used as a proxy of the dynamic and contrast range of valence/arousal. The dynamic range may not be captured by holistic lexical mean measures. For example, in the sentence "And then a silence fell over the crowd, from the front first, so that a chill seemed to spread down the corridor" (Rowling, 1999), a high lexical arousal-span is produced by the contrast between the low arousal of "silence" and the high arousal of "chill", whereas the mean lexical arousal of the whole sentence would be rather moderate. Using data from a recent study by Lehne, Engel, Menninghaus, Jacobs, and Koelsch (in revision), Jacobs (2014) showed that arousal-span can account for about 25% of the variance in suspense ratings from readers of E.T.A. Hoffmann's black-romantic story „The Sandman". Study 1 in Chapter 2 will further investigate the validity of using inter-lexical variables with both arousal- and valence-spans to estimate the emotion potential of literary texts.

1.3.3 Affective processing in literary reading at the supra-lexical level

Beyond the levels of single words and their combination, many factors contribute to a text's emotion potential at the supra-lexical level. A few contributing factors of the emotional reading experience will be summarized below in the context of the dual-route reading model (Jacobs, 2011, 2014).

1.3.3.1 The affective processing of background elements at the supra-lexical level

The discussion on contributing factors of supra-lexical affective effects can be started from the basic assumption that the holistic affective effect of literary texts should consist of at least affective effects from implicit processing at the lexical, inter-lexical, and sublexical level. We have introduced the operationalization of the estimation of the emotion potential at the lexical (Bestgen, 1994) and inter-lexical levels (the arousal-span). At the sublexical level, the phonological salience of a text can be quantified by the tool developed by Aryani, Jacobs, and Conrad (2013). While the operationalization at more basic levels could be rather straightforward, the difficulty is much higher for the supra-lexical levels. Considering that the semantic representation (including affective features like emotional connotations and reference to a certain discrete emotion) of a text could be determined by the semantic associates of the comprising words, the operationalization could be performed with the Associative Read-Out Model (AROM) by Hofmann et al. (2014; 2011).

As summarized in Section 1.2, text comprehension involves inference making and situation model building/updating. Previous studies indicated that the emotion aspect of situation model processing involves activation in aTL, vmPFC, left amygdala, and pons (Ferstl et al., 2005; Ferstl & von Cramon, 2007). It is in line with the results of a meta-analysis of 120 fMRI studies on semantic processing using single words as stimuli, showing that aTL and vmPFC are both important for high-level, multi-modal semantic integration, especially for emotional semantic processing (Binder & Desai, 2011; Binder, Desai, Graves, & Conant, 2009).

During text comprehension, elaborative inferences can be used to infer the emotional state of the protagonist of a story, e.g., if a text describes a person slamming a door after having heard bad news, we may infer that this person is angry, even though their emotional state is not explicitly stated. Empathy and ToM processes are critical for the simulative perspective taking. Walter (2012) differentiated *cognitive ToM, affective ToM*, and *affective empathy. Cognitive ToM* is to mentalize about cognitive states of others, which involves TPJ, STS, dmPFC, and PCC/precuneus. *Affective ToM* is also termed as *cognitive empathy*, which is to mentalize about affective states of others without necessarily being in an affective state oneself. Its neural correlates comprised vmPFC. Last but not least, *affective empathy* has the following features: it is 1) an affective state that is 2) elicited by the perceived, imagined, or inferred state of the affective state of another; 3) is similar to the other's affective state; 4) is oriented towards the other and 5) includes at least some cognitive appreciation of the other's affective state comprising perspective taking, self–other distinction, and knowledge of the causal relation between the self and the other's affective state. The *affective empathy* network contains the anterior insula, the mid-cingulate cortex (mCC), the amygdala, the secondary somatosensory cortex, and the IFG. Among them, anterior insula and mCC are considered to be the core regions of the networks. Meanwhile, they have also been identified as the core neural substrate of pain empathy in a meta-analysis by Lamm et al. (2011), and hypothesized to generate meta-representations of "global emotional moments" (Craig, 2002, 2003, 2009). Vicarious fear which readers perceive through the process of affective empathy (Walter, 2012) and perspective simulation (Gygax, Tapiero, & Carruzzo, 2007; Oatley, 1995, 1999) has been proposed to be involved in the suspense building process (Jacobs, 2014; Lehne et al., in revision).

The affective empathy process is also proposed to be involved in the family of phenomena called immersion (Jennett et al., 2008; Ryan, 1991; Schrott & Jacobs, 2011; Visch, Tan, & Molenaar, 2010), transportation (Gerrig, 1993; Green, 2004; Green & Brock, 2000), absorption (Wirth, Hofer, & Schramm, 2012), presence (Vorderer, Klimmt, & Ritterfeld, 2004), or flow (Csikszentmihalyi, 1975). Immersion has been described as a feeling of "getting lost in a book" (Nell, 1988), or "forgetting about the world around oneself" (Appel, Koch, Schreier, & Groeben, 2002). In the neurocognitive poetics model, Jacobs (2011, 2014) proposed the *fiction feeling hypothesis*, according to which narratives with emotional contents invite readers more to be empathic with the protagonists and thus engage the *affective empathy* network of the brain more likely than stories with neutral contents which should further facilitate immersive reading experience. Study 2 in Chapter 3 will provide more evidence for the correlation between emotional valence, affective empathy, and immersive reading experience proposed in the *fiction feeling hypothesis.*

Appel et al. (2002) formulated a set of standard rating questionnaire to quantify the following aspects of subjective reading experience: suspense, immersion, action density, emotion involvement, vividness (of the fictive world), identification, parasocial interaction, etc. Furthermore, suspenseful film watching experiences have been investigated (Carruthers & Taggart, 1973; Hubert & de Jong-Meyer, 1991) with autonomic (heart rate, skin conductance, and the effect of "sinus arrhythmia"), endocrine (salivary cortisol), and metabolic measures (plasma free fatty acids and triglycerides).

1.3.3.2 The affective processing of foregrounding elements at the supra-lexical level

Foregrounding elements lead to defamiliarization effects and bring about aesthetic pleasure (Miall & Kuiken, 1994; Van Peer, 1986, 2007; Van Peer & Hakemulder, 2006). Upon meaning construction in reading, when the created *meaning gestalts* (Iser, 1976) are open to many different possible interpretations, like ambiguous figures or visual illusions in the *perceptive gestalt*, the feeling of tension is triggered. According to the Structural-Affect Theory of stories by Brewer and Lichtenstein (1982), the feeling of tension asks for an outcome as a closure, or resolution, of the *meaning gestalts.* This experience corresponded to the *aesthetic trajectory hypothesis* of Fitch, Graevenitz, and Nicolas (2009), according to which aesthetic experiences follow a three-phasic dynamics of 1) implicit recognition of familiar elements, 2) surprise, ambiguity, and tension elicited by unfamiliar (i.e., foregrounded) elements, and 3) resolution of the created tension. However, according to Iser (1976), the aesthetic experience in reading consists of constant oscillations between illusion-formation and revision, frustration, and surprise. Thus, the resolution phase is probably never really completed in many real-life reading experiences, since the *meaning gestalts* are always open to new interpretations and reflections. Examples of devices that create open *meaning gestalts* and the consequent tension experience include a *cliffhanger* ending of a fiction, or literary materials that are unfamiliar and figurative, e.g., novel metaphoric noun-noun compounds consisting of two semantically distant words like "plastic-oath" or "music-soup" (Forgacs et al., 2012).

Among recent neuroimaging studies on the effect of foregrounding, Bohrn, Altmann, Lubrich, Menninghaus, and Jacobs (2012) investigated the potential neural correlates of defamiliarization effects with fMRI: defamiliarized proverb variants enhanced activation in bilateral aTL, OFC, vmPFC, dmPFC, PCC, and PHC, which are associated with emotional semantic processing, emotion conceptualization or evaluation (Binder & Desai, 2011; Binder et al., 2009; Lindquist et al., 2012). The authors concluded that defamiliarization can influence the affective and esthetic processing of literature.

The use of figurative language (e.g., metaphors, idioms, sarcasm/irony) in literary texts has also been shown to modulate affective processing in text comprehension. In a meta-analysis (Bohrn, Altmann, & Jacobs, 2012), figurative language processing was shown to elicit stronger activation than literal counterparts in emotion associated brain regions such as bilateral aTL, vmPFC, and left amygdala with medial globus pallidus. In addition, subjectively funny verbal jokes have been shown to activate vmPFC more than non-funny jokes (Goel & Dolan, 2001). The activation of the left amygdala by figurative language indicates that it is more salient (Seeley et al., 2007), possesses higher emotional relevance (Sander, Grafman, & Zalla, 2003) and/or affective intensity (Costafreda et al., 2008) that make figurative language a key feature of rhetoric and poetic texts.

In situation model processing, the current linguistic input is integrated with both general world knowledge and the prior discourse context (Graesser et al., 1997; Zwaan & Radvansky, 1998). This process is proposed to take place in the left IFG (Hagoort, 2005), part of the ELN (Ferstl et al., 2008), which is supported by studies showing that world knowledge violation caused stronger activation in LIFG (Hagoort et al., 2004), or bilateral IFG (Menenti et al., 2008). Study 3 in Chapter 4 will investigate the effect of world knowledge violation and the associated surprise brought about by texts containing supranatural contents.

1.4 Differences in holistic emotion processing in literary reading in L1 vs. L2

After the level-wise dissection of the emotion potential of literary reading, this dissertation will go further to investigate the effect of the factor bilingualism. Numerous results from behavioral or psychophysiological data suggested an attenuation of emotionality in L2 compared to L1 (Bond & Lai, 1986; Gonzalez-Reigosa, 1976; Harris, 2004; Harris, Aycicegi, & Gleason, 2003; Keysar, Hayakawa, & An, 2012; see Pavlenko, 2012, for a review), yet many recent studies argued that emotionality in L2 is modulated by factors such as age of acquisition, proficiency, and exposure, and can reach the same intensity as emotionality in L1 (Ayçiçeği-Dinn & Caldwell-Harris, 2009; Conrad et al., 2011; Harris, Gleason, & Ayçiçeği, 2006; Wu & Thierry, 2012). Neuroimaging studies of bilingualism investigating the difference of neuroanatomical loci associated with the processing of L1 and L2 in late bilinguals using single words, sentences, and short stories provided equivocal results, while proficiency and age of acquisition (AoA) are considered to be highly relevant (for reviews, see Fabbro, 2001; Van Heuven & Dijkstra, 2010). By looking at the neuroimaging data of a group of participants with adequate and consistent L2 proficiency, Study 4 in Chapter 5 will investigate the quantitative and qualitative differences of emotion processing in literary reading.

1.5 Principles of functional Magnetic Resonance Imaging (fMRI)

Since all studies presented in this dissertation use functional magnetic resonance imaging (fMRI), a short overview of the method is given. The nucleus of an atom consists of protons and neutrons; both of them spin about their axis, and their spinning produces angular momentum. When there is an uneven number of protons and neutrons in one atomic nucleus, it possesses angular momentum. Since a proton has a positive charge, the spinning of protons produces magnetic momentum. The ratio between the angular momentum and the magnetic momentum is the *Gyro Magnetic Ratio* (γ). Among those magnetically active atomic nuclei, hydrogen proton has the highest gyro magnetic ratio, and is very abundant in human bodies; therefore it is used for the imaging of human beings.

In an externally applied static magnetic field (B_0), the hydrogen protons will align with the magnetic field in either parallel or anti-parallel orientations. Protons aligning in parallel orientation are in lower energy state; protons aligning in anti-parallel orientation are in higher energy state. The stronger the B_0, the more protons align in parallel orientation. Meanwhile each proton precesses due to the magnetic momentum of the atom. The frequency of hydrogen precession is the *Larmor frequency* (ω_0), which could be calculated from the equation: $\omega_0 = \gamma B_0$. The net magnetization of all magnetic momentums of protons in B_0 – the longitudinal magnetization – would be in the same direction as B_0.

Radio wave is an oscillating electromagnetic field. When applying a Radio Frequency (RF) pulse at the Larmor frequency of the system with adequate amplitude for a certain period of time, which is the process of excitation, the net magnetization could be rotated toward a plane perpendicular to the Z-axis. The angle of rotation is the Flip Angle (FA).

The excited protons are in a higher energy state, and they would undergo relaxation process to return to a lower energy state, during which the absorbed energy is released in forms of heat and RF waves to the surrounding tissue. T1 relaxation, longitudinal relaxation, or Spin-Lattice relaxation, describes the process that the net magnetization rotates back to the direction of B_0, and re-growth of longitudinal magnetization. T1 is defined as the time it takes for the longitudinal magnetization to reach 63 % of the original magnetization.

Upon excitation, the protons in the system also start to spin in-phase, which means that magnetic vectors of individual protons point to the same direction while spinning. T2 relaxation, transverse relaxation, or Spin-Spin relaxation, describes the process of de-phasing from in-phase to a total out-of-phase situation due to the interaction between protons and their immediate surroundings. T2 is defined as the time it takes for the spins to de-phase to 37 % of the original value.

In physiological tissue, the magnetic field inhomogeneity and chemical shift could further disrupt the phase coherence in T2 relaxation, and cause the loss of signal, or Free Induction Decay (FID). The corresponding relaxation time T2* is usually much smaller than T2.

In Spin Echo Sequence, by manipulating the sequence parameters Repetition Time (TR) and Echo Time (TE), it is possible to highlight tissues with different properties in T1 or T2 relaxation, and hence different image contrasts. Repetition time is the time between two excitation pulses; echo time is the time between the excitation pulse and the echo. A combination of short TR and short TE would produce the T1 contrast; a combination of long TR and long TE would produce the T2 contrast; a combination short TR and long TE would be a mix of T1 and T2 contrasts, and hence the Proton Density Contrast.

For spatial reconstruction in each slice, frequency and phase encoding are enclosed in k-space and then reconstructed with Fourier transform into images.

Functional Magnetic Resonance Imaging measures hemodynamic responses such as changes in blood volume, blood flow, and blood oxygen level related to neural activities in the brain or spinal cord. The Blood Oxygen Level Dependent (BOLD) signal is a T2* weighted contrast. Hemoglobin is diamagnetic when oxygenated and paramagnetic when deoxygenated. The deoxygenated hemoglobin, but not oxygenated hemoglobin would contribute to the local magnetic field inhomogeneity in brain. The FID would be faster if the concentration deoxygenated blood is higher, and cause weaker signal in T2* contrast. Therefore, higher level of blood oxygenation results in stronger BOLD signal.

Increase in neural activity induces the increase of cerebral blood flow, which overcompensates for the decrease in cerebral blood oxygen resulted from increased brain consumption. Therefore, the observed BOLD signal would increase with increased regional neural activity. The reason for the mismatch between the supply and demand of blood oxygen is still unclear. One hypothesis is that vasculatures deliver a fixed ratio of oxygen and glucose; in order to meet the glucose demand of both aerobic and anaerobic processes, the oxygen has to be oversupplied when neural activity increases. The other hypothesis claims that oxygen delivery is inefficient in brain; in order to increase the delivery rate of oxygen into neurons, the oxygen has to be oversupplied.

In comparison with EEG and MEG, functional MRI provides high spatial resolution up to 1 mm, and signal from deep brain regions can also be measured. However, the BOLD signal is an indirect measurement of neural activity, and the relationship between BOLD signal and neural activity is not linear. In contrast, EEG and MEG directly measure the brain electromagnetic signal. In addition, the BOLD signal reaches the peak 5 to 9 seconds after the change of the neural activity, therefore provides poorer temporal resolution than EEG and MEG do.

1.6 The use of reverse inference

The classic strategies for researchers to interpret neuroscientific data are 1) forward inference: identifying the localized effects of the experimentally manipulated psychological function on brain activity (Henson, 2005), 2) reverse inference: backward reasoning from patterns of activation to infer the engagement of specific mental processes (Poldrack, 2006, 2011). The extensive usage of reverse inference for neuroimaging studies has been criticized by Poldrack (2006) for the lack of one-to-one specificity between brain activation and cognitive process. Poldrack (2006, 2011) proposed to use Bayes' theorem and large-scale databases of neuroimaging studies to estimate the selectivity of brain activity and the legitimacy to use reverse inference. One fruitful example of such proposal is the Neurosynth (http://www.neurosynth.org), in which Yarkoni, Poldrack, Nichols, Van Essen, and Wager (2011) used the automatically extracted activation coordinates for 3,489 published articles, along with the full text of those articles to estimate how well one can predict the presence of a particular term in the paper given activation in a particular region.

While reverse inference has since been considered as a fallacy after Poldrack (2006), Hutzler (2014) emphasized the importance of the consideration of task-setting. Without considering task-setting, the probability by which the cognitive process occurs during a specific task would be wrongly estimated. He revised the formulation for calculating the Bayes' factor of the reverse inference, which allows an estimation of reverse inference on the basis of meta-analyses instead of large-scale databases. Meta-analyses provide the advantage of a fine-grained categorization of comparisons on the basis of a cognitive analysis done by experts in the respective domain, while the coding of cognitive processes in large-scale databases can be imprecise or confusing[1]. With the revised formu-

[1] The automated algorithm of Neurosynth (Yarkoni et al., 2011) uses user-entered search string in an unspecific way to retrieve articles and peak-coordinates to perform meta-analyses. Articles that mention the keyword but

la on the basis of meta-analysis, he showed that reverse inference can have high predictive power.

The current dissertation investigates a pioneering research topic, the emotion processing in literary reading. As summarized in Section 1.1 – 1.3, literary reading is a complex process containing numerous sub-processes that take place simultaneously. Current neurocognitive knowledge on the research topic is not yet clear and extensive enough to allow the author to pose precise hypothesis about the causal relationship and interaction between potential neural correlates/networks. For example, for a network modeling, it is required to know the involved neural regions, the existing physiological connection between them, and on which region and physiological connection the psychological manipulation might exert effect. Despite the experimental manipulation and the careful control of confounding covariates, in one fMRI contrast, one often observes many discrete clusters of differential activation or parametric effects. Using forward inference would attribute all significant brain regions onto a relatively holistic and coarse label that one contrast represents. Therefore inevitably, efforts have to be made using reverse inference to attribute certain significant regions to some known sub-processes. When using reverse inference in the present dissertation, the author considered task-setting (literary/fictional reading) and primarily considered information provided by meta-analyses on the emotion processing (Costafreda et al., 2008; Lindquist et al., 2012; Murphy, Nimmo-Smith, & Lawrence, 2003; Phan, Wager, Taylor, & Liberzon, 2002; Phan, Wager, Taylor, & Liberzon, 2004), text comprehension (Ferstl et al., 2008), semantic processing (Binder et al., 2009), affective empathy (Lamm et al., 2011), and ToM processes (Mar, 2011), which represent reproducible associations between a certain task and the localized brain activity. This process serves in these pioneer studies to formulate further heuristic hypotheses on details concerning the model of literary reading. Efforts have also been made in Study 4 to use MVPA to differentiate/decode different activation patterns under different emotion conditions, as proposed by (Poldrack, 2011).

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not investigate the keyword-specific task-setting can also be included in the automated meta-analyses. Furthermore, there is the problem that a single keyword could infer to a domain of several cognitive processes, and different authors use different terms to describe the same process. They all limit the reliability of the statistics offered.

1.7 The Harry Potter experiment

Studies in this dissertation use data from one fMRI and several behavioral experiments[2]. The general design is described below, while the relevant details are given in each chapter for individual studies. In order to address the research questions in a more natural reading context and to tap into typical everyday reading experience, entire text passages were visually presented from the popular book series "Harry Potter" instead of single words or sentences used as stimuli in comparable previous studies. In a pilot rating study, 15 native German speakers rated the published German translations of 239 potential suitable passages (by Klaus Fritz, Carlsen Verlag, Hamburg) on the four emotional dimensions: valence, scaled from -3 (very negative) to +3 (very positive, see Võ et al., 2006); arousal, scaled from 1 (very calming) to 5 (very arousing, see Bradley & Lang, 1999; Võ et al., 2009; Võ et al., 2006); fearfulness, scaled from 1 (not fear-inducing at all) to 5 (very fear-inducing); and happiness, scaled from 1 (not happy at all) to 5 (very happy). Based on the results of the pilot study, one hundred and twenty text passages of four lines long were finally selected as stimuli, including 40 passages in the "Fear" condition, the "Happy" condition, and the "Neutral" condition.

Passage selection assured that: 1) understanding the passages did not require a high level of familiarity with HP novels, 2) the emotional connotations of the passages clearly evolved at their very beginning, 3) respective emotional contents were unambiguous and consistent throughout the passage. Across the three emotional categories, we matched the number of persons or characters (as the narrative element), the type of intercharacter interaction, and the incidence of supra-natural events (i.e., magic) involved in text passages. Within each language, we also matched the numbers of letters, words, sentences, and subordinate sentence per passage across the three emotional categories. For the German passages, for which all these measures were available, we matched the passage-wise average imageability (taken from Võ et al., 2009; Conrad et al., unpublished results) and passage-wise average frequency of words given in SUBTLEX (Brysbaert et al., 2011), and Leipzig Wortschatz Project (available at http://wortschatz.uni-leipzig.de/) across the three conditions.

Independent of the emotional categories, among the 120 passages are twenty passages describing supra-natural events and twenty passages devoid of supra-natural events as the control counterparts of the supra-natural ones. The supra-natural and control pas-

[2] Another fMRI experiment investigating specifically the sublexical level was also performed, but despite extensive analyses, the results remain inconclusive at the current stage.

sages are controlled for valence and arousal ratings from the pilot study, the number of persons or characters, the type of inter-character interaction, length (the numbers of letters, words, sentences, and subordinate sentences), word imageability and word frequency.

The fMRI experiment consisted of four runs, each containing five passages from each language-emotion condition. Each run also contained five supra-natural, five control passages, and twenty passages irrelevant for the analysis of supra-naturalness. The order of presentation of the 30 passages was pseudo-randomized in each run. Not counting the first and last passages, we always assured equal numbers (seven) of all possible language switch combinations (E-E, E-G, G-E, G-G) in each run. Across all participants, the distribution of valence categories relative to these switch positions was balanced; the distribution of the presented language in supra-natural vs. control conditions across all runs was also balanced.

Each passage was presented for 14 s in the MR scanner, distributed on four lines (shown consecutively for 3.5 s each), and then followed by 14 s of fixation cross. The visual input was presented on a computer screen and was reflected to the participants' eyes via a mirror. To keep participants attentive, four randomly selected passages in each run were immediately followed by an emotion-unrelated, context-specific yes/no question (e.g. 'Was Harry in a train station?' 'Was the alarm clock broken again?'), to which participants responded via button press. Each question was presented for four seconds, which included the time for response (Fig. 1.4).

Following the experiment in the MR scanner, participants rated all 120 passages in the language version they had read inside the scanner, but in a different pseudo-randomized order, on the four dimensions of valence, arousal, fearfulness, and happiness using identical scales as for the pilot ratings. For study two and three, other post-hoc ratings were collected from different groups of native German speakers.

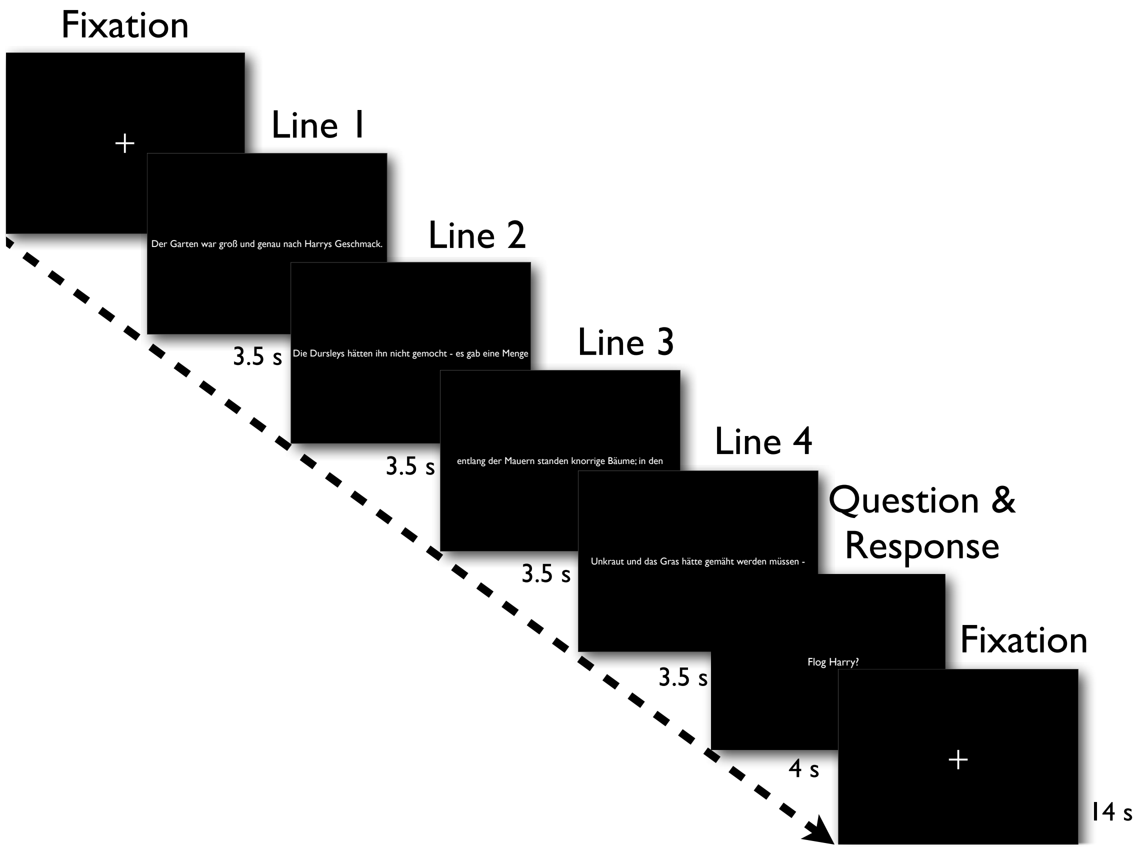

Fig. 1.4. The schematic presentation of the experimental procedure in the MR scanner.

1.7.1. Chapter 2: the emotion potential of words and passages in reading

Study 1 focuses on the background processes of fast and automatic word recognition, sentence and text comprehension, forming the upper route of the neurocognitive poetics model of reading (Fig. 1.3, blue rectangular). It aims to investigate the differential contribution of lexical, inter-lexical, and supra-lexical factors to the emotion potential of texts (section 1.3.1 & 1.3.2). For that purpose, affective lexical variables, i.e., mean lexical valence and arousal and lexical valence- and arousal-span, were calculated based on a German normative database for lemma forms of single words contained in the passages (Conrad et al., in prep., see also BAWL-R, Võ et al., 2009, and ANGST, Schmidtke et al., 2014). At the behavioral level, the bivariate correlations between passage affective lexical variables and mean subjective ratings are calculated. At the neuronal level, three models of parametric analyses were performed to disentangle specific effects of lexical, inter-lexical, and supra-lexical level variables after factoring out shared variance from other levels.

1.7.2. Chapter 3: fiction feeling, affective empathy, and immersive reading experience

Study 2 focuses on different parts of the upper route of the reading model: the background processes of fiction feelings, empathy, and immersion (Fig. 1.3, green rectangular). It aims to test the *fiction feeling hypothesis* proposed by Jacobs (2014), i.e., narratives with emotional contents invite readers more to be empathic with the protagonists and thus engage the affective empathy network of the brain, anterior insula and mCC (dorsal ACC), more likely than stories with neutral contents, which should further facilitate immersive reading experience (section 1.3.3.1). To do so, we collected post-hoc immersion ratings from 20 native German speakers, and performed parametric analyses using mean passage immersion ratings as modulators separately for passages in Fear and Neutral conditions that were read in German. We then compared the beta-values of the parametric analysis in two conditions to test whether in the anterior insula and mCC, the neural activity is more correlated with immersion ratings when reading fear-inducing than neutral passages.

1.7.3. Chapter 4: how descriptions of supra-natural events entertain and enchant

Study 3 investigates the turning point when the background process of implicit situational model construction is interrupted by contents of world-knowledge violation (section 1.3.3.2), which catches readers' attention, turns the process of situation model updating explicit, and probably creates feelings of surprise or fascination (Fig. 1.3, red arrows). It is hypothesized that the violation of world knowledge should increase the cognitive demand of world knowledge integration, and that the related novelty, unexpectedness, and uncertainty should activate the salience/emotion network (Lindquist et al., 2012; Seeley et al., 2007), which should further recruit fronto-parietal attention networks (Corbetta et al., 2008; Corbetta & Shulman, 2002; Pourtois et al., 2013). Based on the supra-naturalness manipulation, we checked brain regions with differential activation between the Supra-natural and Control conditions to test the hypothesis.

1.7.4. Chapter 5: can Harry Potter still put a spell on us in a second language?

This dissertation ends with Study 4 investigating the general differences in emotion processing when reading in L1 vs. L2 (section 1.3). At the neuronal level, two kinds of difference in emotion processing could be expected: 1) quantitative: an attenuated emotionality of L2 processing, if observable, should result in decreased sensitivity of amygdala to the emotion manipulation in the L2 text passages; 2) qualitative: if the intensity of emotionality of L2 processing is the same as in L1, it is possible that the spatially distributed activation pattern is still different. For the quantitative difference, a factorial analysis was performed based on the design of Emotion × Language to check for emotion-associated neural correlates where the interaction between emotion and language takes place. For the qualitative difference, multivariate pattern analysis is performed to test whether distributed brain activity patterns differ when reading literature in L1 and L2, and whether levels of pattern differentiation when reading text of different emotion categories differ between L1 and L2.

1.8 Hypotheses on neural correlates of emotion processing in literary reading

Considering current knowledge about emotion processing and reading, there are various theories concerning possible neural correlates of emotion processing in reading: 1) the neural re-use, 2) the classical psycholinguistic perspective, 3) perspective simulation and identification, and 4) embodied or grounded emotion. This dissertation will provide evidence to that may help to evaluate respective theories.

The theory of neural-reuse proposes that neural circuits established for one purpose to be reemployed during evolution or normal development, and can be put to different uses, often without losing their original functions. Therefore, neural substrates of responsible for the processing of emotional aspects of a variety of stimuli as occurring in our original environment (faces, pictures, odors) might be in charge of the emotion processing in literary reading as well (Anderson, 2010). This theory would predict that activities in the salience or emotional network (Lindquist et al., 2012; Seeley et al., 2007) can also be modulated by the emotionality of the texts.

The classical psycholinguistic hypothesis proposes that emotional responses to literary texts are generated within the reading network itself (Ponz et al., 2013). It would predict that activity in the ELN (Ferstl et al., 2008) and regions of multi-modal semantic integration (Binder & Desai, 2011; Binder et al., 2009) are correlated with the emotionality of the texts read.

The theory of perspective simulation and identification (Oatley, 1995, 1999) suggests that readers enter the fictive world created by the writer, empathize the protagonists with personal memories of emotion, and identify themselves with protagonists' goals and plans. It would predict that the emotionality of the text correlates with activity in the ToM or *affective empathy* network (Mar, 2011; Walter, 2012). This theory will also be specifically tested in Study 2 (Chapter 3) in the form of *fiction feeling hypothesis* (Section 1.7.2).

Finally, the theory of embodiment or grounded emotion (Niedenthal, 2007) suggests that readers would re-experience emotions in perceptual, somatovisceral, and motoric modules. Moseley, Carota, Hauk, Mohr, and Pulvermuller (2012) have demonstrated that emotion-laden words indeed activate pre-central cortex, including body-part-specific areas that are somatotopically activated by face- or arm-related words. Accordingly, this theory would predict correlated activation in the motor, premotor, and somatosensory regions for emotion-laden texts.

Respective hypotheses derived from these theories are not meant to be mutually exclusive. As summarized before, literary reading contains multiple parallel processes. Empirical evidence already showed that the salience/emotion network and motor-associated brain regions are involved when processing emotion-laden words visually (Citron, 2012; Moseley et al., 2012; Ponz et al., 2013). It is likely that these regions are also involved when reading emotion-laden texts simply because of the emotion-laden words contained, but also because emotional lexical surface features may play a very specific role in text reading, which corresponded to the research question of Study 1 (the emotion potential of words in literary reading). If one considers that the processing of complex texts is based on representations of rather basic, embodied, concepts, one would expect results of the dissertation to be in line with the neural re-use and embodied hypotheses. On the other hand, there is also evidence (Altmann et al., 2012) that the increase of negative valence of story contents activates the mentalizing network (*cognitive* and *affective ToM*), which supports the perspective simulation and identification hypothesis. Whereas the classical psycholinguistic hypothesis remains to be tested, the anatomical overlap between, e.g., the ELN and ToM network (especially the aTL is associated with reading, semantic integration, and salience network at the same time) makes it plausible that the present study may provide some support for it. At least, it should certainly provide fruitful empirical evidence for the further discussion and comparison of these four hypotheses that are neither isolated nor mutually exclusive.

2. The Emotion Potential of Words and Passages in Reading[3]

Chun-Ting Hsu, Arthur M. Jacobs, Francesca M.M. Citron, Markus Conrad

Abstract

Previous studies suggested that the emotional connotation of single words automatically recruits attention. We investigated the potential of words to induce emotional engagement when reading texts. In an fMRI experiment, we presented 120 text passages from the Harry Potter book series. Results showed significant correlations between affective word (i.e., lexical) ratings and passage ratings. Furthermore, affective lexical ratings correlated with activity in regions associated with emotion, situation model building, multimodal semantic integration, and Theory of Mind. We distinguished differential influences of affective lexical, inter-lexical, and supra-lexical variables: differential effects of lexical valence were significant in the left amygdala, while effects of arousal-span (the dynamic range of arousal across a passage) were significant in the left amygdala and insula. However, we found no differential effect of passage ratings in emotion-associated regions. Our results support the hypothesis that the emotion potential of texts can be predicted by lexical and inter-lexical affective variables.

[3] This chapter was under review by *Brain and Language* as "The Emotion Potential of Words and Passages in Reading Harry Potter - An fMRI Study" at the time of dissertation submission.

2.1. Introduction

Literary reading of novels or poems brings pleasures, including feelings of suspense, vicarious joy (or fear), or beauty, which are unique and important to human beings (Brewer & Lichtenstein, 1982; Nell, 1988). However, the neurocognitive processes underlying these feelings are poorly understood (Kringelbach et al., 2008; Schrott & Jacobs, 2011; Wolf, 2007). A recent neurocognitive poetics model of literary reading (Jacobs, 2011, 2014) has attempted to link the findings from the few existing neurocognitive studies on literary reading with results from cognitive linguistics, poetics, and aesthetics, by formulating hypotheses about which text elements evoke cognitive, emotional, or aesthetic processes. According to the model, literary reading can be viewed as a process of constructive content simulation (Mar & Oatley, 2008), closely linked to perspective taking and relational inferences associated at the neural level with the activation of the extended language network (ELN, Ferstl et al., 2008), the Theory of Mind (ToM) network (Mason & Just, 2009), brain regions associated with affective or mood empathy (Altmann et al., 2012, 2014; Frith & Frith, 2003; Lüdtke et al., 2014; Mar & Oatley, 2008), the creation of "event gestalts" (Speer et al., 2007), and with reward and aesthetic pleasure (Bohrn et al., 2013). These processes converge to fulfill the goal of literary reading, i.e., meaning construction and the closure of *meaning gestalts* which depends on many factors, including the affective meaning of single words and passages (Iser, 1976; Jacobs, 2014).

At the cognitive level, discourse comprehension involves at least three different processing steps (Schmalhofer & Glavanov, 1986; Van Dijk & Kintsch, 1983): 1) the construction of the *surface structure* of a text, which is a mental representation of the exact text read; 2) a *text-base representation*, which contains idea units explicitly stated in the text, including bridging inferences that help connecting consecutive clauses; and 3) a *situation model* of the text, in which the current linguistic input (i.e., the linguistic meaning of the sentence or paragraph being read) is integrated with both general world knowledge and the prior discourse context (Graesser et al., 1997; Zwaan & Radvansky, 1998).

Affective aspects of discourse comprehension seem to involve embodied representations evoked through empathy, the simulation of emotion-related behavior, and autobiographical emotions related to memories of similar events. Empirical studies investigating emotional inferences during text comprehension (Gillioz, Gygax, & Tapiero, 2012; Gygax et al., 2007) have shown that the protagonist's behavioral reactions to an event are likely to be an important component of emotional inferences in discourse comprehension, and are highly associated with the emotional arousal level of the protagonist's behavior. Neuroscientific evidence that the affective aspect of meaning construction is possibly based on perspective simulation comes from an fMRI study of Moseley et al. (2012), who demonstrated that emotion-laden words indeed activated precentral cortex, including body-part-specific areas that are somatotopically activated by face- or arm-related words.

All these views on discourse processing suggest that affective processes during text reading may require more complex processes than those elicited by the emotion potential of single words as suggested by Jacobs (2014).

Regarding the emotion potential of literary texts at the neuronal level, Ferstl et al. (2005) were the first to show that listening to emotion-laden text passages indeed activates affect-related brain areas like the ventromedial prefrontal cortex (vmPFC), the left amygdala, and the pons. By auditorily presenting a near complete recording of "*The Ugly Duckling*" to participants, Wallentin et al. (2011) reported the neural correlates of intensity ratings of each line of the text, i.e., the bilateral temporal, inferior frontal and premotor cortices, the thalamus, and the right amygdala. However, further neuroscientific evidence is still scarce (e.g., Bohrn et al., 2013; Hsu, Conrad, & Jacobs, 2014; Hsu, Jacobs, & Conrad, 2015; Lehne et al., in revision) compared to the more substantial body of research on the relationship between language and emotion using words in isolation (see Citron, 2012, for a review).

The emotion potential of words is usually operationalized in terms of valence and arousal ratings: the former refers to how positive or negative a word is, whereas the latter refers to its physiological intensity (Bradley & Lang, 1999; Osgood, 1969). These properties are normally distributed across all words, which can be categorized into negative, neutral, and positive classes (see Jacobs et al., in prep.; Schmidtke, Schröder, Jacobs, & Conrad, 2014; Võ et al., 2009; Võ et al., 2006, for normative German lexical databases), and have significant effects at the three relevant psychological levels: the experiential (e.g., subjective ratings, self-reports; Võ et al., 2009; Võ et al., 2006), the behavioral (e.g., response times, oculo- and pupillometric responses; Briesemeister et al., 2011a, 2011b; Võ et al., 2006; Võ et al., 2008), and the neuronal level, using both electrophysiological (e.g., Briesemeister et al., 2014; Conrad et al., 2011; Fischler & Bradley, 2006; Hofmann et al., 2009; Recio et al., 2014) and functional neuroimaging methods (e.g., Citron et al., 2014; Kuchinke et al., 2005). In particular, neuroscientific research on emotion-laden word processing using event-related potentials (ERP) has shown that such words capture attention more strongly than neutral words since early processing stages (e.g., Citron, Weekes, & Ferstl, 2013; Fritsch & Kuchinke, 2013; Hofmann et al., 2009; Kissler et al., 2006; Kissler, Herbert, Peyk, & Junghofer, 2007; Schacht, Adler, Chen, Guo, & Sommer, 2012; see Citron, 2012, for a review). The attention capture seems to be automatic, i.e., it occurs even when participants attend to non-emotional features of the words (e.g., Scott, O'Donnell, Leuthold, & Sereno, 2009), and it can also occur in the absence of conscious perception (Straube, Sauer, & Miltner, 2011).

In the present study, we addressed the question to what extent the emotion potential of supra-lexical units like narrative text passages is a function of the affective values of their constituting words, as proposed by Bestgen (1994) and by Whissell (2003b; see also Jacobs, 2014).

Certainly, one might wonder to what extent findings for isolated words could generalize to the processing of larger text units and literary reading. A text is more than a list of words, and the way these words are combined, or the context they are embedded in, clearly matter. For example, basic phenomena such as negation, or more sophisticated rhetorical elements like metaphor or irony, can turn the emotional information of a text unit into the opposite of what single words' emotional content might suggest (Nagels et al., 2013; Regel, Gunter, & Friederici, 2011).

ERP studies have addressed the issue of how emotionally relevant sentence context influences the way in which the brain processes otherwise identical lexical material. Van Berkum, Holleman, Nieuwland, Otten, and Murre (2009) reported increased N400 amplitudes for target words whose combination with the preceding sentence context resulted in a moral statement that was inconsistent with the reader's political attitude. Schauenburg, Conrad, Ambrasat, Von Scheve, and Schröder (2013) extended this finding to the inconsistency concerning the general emotional content of single words across sentences describing social interactions. Their findings suggested that supra-lexical phenomena – like the relation between words within a sentence – affect emotion processing during sentence reading. In contrast, other ERP studies have shown that emotional features of single words can also reduce general context effects like the N400 component, which is typically interpreted to reflect increased difficulty of semantic integration into context. In the study of Delaney-Busch and Kuperberg (2013), incongruent context only modulated N400 amplitudes for neutral, but not for emotion-laden words, whereas N400 amplitudes were generally decreased for the latter. This suggests that emotional salience ensures a partly context-independent processing of single lexical units, which "pop out" of context because of their general emotional relevance. In another study, Wang, Bastiaansen, Yang, and Hagoort (2013) presented question-answer pairs. Each answer contained a critical word (either positive, negative or neutral) that could be either the focus of the question or not. In both studies, the authors reported significant main effects of emotion and of congruency/focus, as well as a significant interaction between them, in the N400 component. Post-hoc analyses showed that the effect of congruency was only significant for neutral words, but not for both positive and negative words. One possible interpretation of the latter findings, proposed by Delaney-Busch and Kuperberg (2013), is that the emotional salience of such words gives rise to their prioritized processing from the earliest stages of meaning extraction, and leads readers to bypass a possible semantic incongruency with context. In this regard, both studies reviewed above suggest that the context-independent, highly automatic attention-capture potential of emotion-laden words can sometimes override integration processes or context effects during discourse comprehension.

In the present study, we attempted to disentangle emotional effects during reading that arise at the lexical level from those that arise at the supra-lexical level. Following Jacobs' (2014) proposal, in the absence of irony or similar stylistic devices, the emotion potential of supra-lexical units such as narrative passages can be hypothesized to be a direct function of the emotion potential of the constituting words. On the other hand, the principle of the whole being more than (or different from) the sum of its parts would predict emotional effects to be a function of more holistic processing of larger units, and thus emotional effects of a passage could not be fully accounted for by the affective values of its constituting words.

In his pioneering study, Bestgen (1994) acquired valence ratings from 120 participants at three different processing levels: 1) the textual level: participants read the text in the context of narrative reading and rated all sentences sequentially; 2) The sentential level: sentences from all four stories were divided into three sets, each including one third of all sentences from each of the four stories, but two sentences from the same story were not presented one after another; 3) The lexical level: words extracted from the four texts, excluding articles, pronouns, prepositions, proper names, and the verbs "to be" and "to have". Bestgen (1994) computed the correlations between the rated valence of the sentences at the textual, sentential, and lexical level (by calculating mean valence values of words composing the sentences), in each of the four texts. The linear correlations between rated valence at the textual and lexical level, and between textual and sentential level were large and significant (between .55 and .84, depending on the text). A similar approach was adopted by Whissell using the *Dictionary of Affect in Language* (Whissell &

Dewson, 1986), which contains valence and arousal ratings of 4500 words as an estimate of the affective tone of existing passages of literature (Whissell, 2003b, 2010, 2011). With principle component analysis, Whissell (2003b) showed that ratings of 20 excerpts of romantic poetry from 68 participants on dimensions of pleasantness, activation, romanticism, and preoccupation with nature were consistent with estimations based on the *Dictionary of Affect*. By comparing two parts of Byron's *Child Harold's Pilgrimage*, written before and after an interruption of several turbulent years in England, Whissell (2010) showed that the later part employed fewer extreme emotional words and more abstract words than the pre-interruption part. Whissell (2011) found evidence for different pleasantness levels in four categories of speech (condescension, control, self-definition, and courtship of good opinion) given by Shakespeare's character Henry V.

We adopted this general approach of estimating a text's emotion potential as a function of affective values of the constituting words and investigated it at the neural level.

The present study

We used text passages from the Harry Potter book series as stimuli, featuring concepts, events and descriptions that display a sufficiently wide range of lexical valence and arousal values. We acquired functional magnetic resonance imaging (fMRI) data to investigate the neural correlates of the emotional potential of narratives, operationalized via: individual emotion ratings of entire passages (termed henceforth "subjective passage ratings"); and normative affective values of their constituting words (termed henceforth "affective lexical variables"). The lexical variables were derived from a recent, large-scale, normative database comprising affective ratings for 6,600 words (Conrad, Schmidtke, Vo, & Jacobs, in prep.), which extends the Berlin Affective Word List (BAWL-R, Võ et al., 2009) and the Affective Norms for German Sentiment Terms (ANGST, Schmidtke, Schröder, et al., 2014). In particular, we use both mean and spread measures of affective lexical variables across a given piece of text because they might represent different specific aspects of the text's emotion potential at the level of lexical surface features: While the mean of lexical valence and arousal values across a text may best represent its emotion potential as a function of the appearance of emotionally rather consistent concepts, spread measures of arousal or valence may, in turn, represent a proxy of dynamic changes or contrasts in the affective reactions a reader experiences. We consider "arousal-span" (i.e., the range of arousal values of single words across a text; see Jacobs, 2014, for a theoretical proposal concerning effects of this measure) and, accordingly, "valence-span" (the range of respective valence values) as the most appropriate lexical spread measures of a text's emotion potential. Using data from a recent study by Lehne et al. (in revision), Jacobs (2014) showed that arousal-span could account for about 25% of the variance in suspense ratings from readers of E.T.A. Hoffmann's black-romantic story „*The Sandman*“.

We used these affective lexical variables and subjective passage ratings as parametric predictors of brain activation, assuming that the former would contribute significantly to the emotional reading experience. At the neuronal level, using parametric fMRI analyses, we expected both the affective lexical and supra-lexical variables to be correlated with BOLD signal intensity in the temporal, inferior frontal and premotor cortices, vmPFC, thalamus, amygdala, and the pons, which have all been reported to be specifically associated with emotional discourse comprehension (Ferstl et al., 2005; Wallentin et al., 2011). In addition, our aim was to disentangle potential differential effects of the following variables that reflect a text's emotion potential at three different levels (see also examples given in Table 2.1):

1) The elementary level of general emotion content of lexical units or concepts – represented by the means of lexical valence and arousal values of single words, appearing in a given text. Note that this operationalization assumes that respective values for single elements (words or concepts) would condense into a homogenous affective impression. An illustrative example from our stimulus material is the sentence "'You disgusting little Squib, you filthy little blood traitor!' roared Gaunt, losing control" (Rowling, 2005), whose lexical units are consistently negative in valence and high in arousal ("disgusting", "filthy", "blood", "traitor", "roar", and "losing");
2) The inter-lexical level, between single words and holistic supra-lexical processing –operationalized by lexical valence- and arousal-span. Note that, in contrast to the mean measures described above, these lexical span measures should especially account for dynamic changes and salient contrasts characterizing the relation between single lexical units and concepts in a text (Jacobs, 2014). These aspects may not be captured by overall lexical mean measures. For example, in the sentence "And then a silence fell over the crowd, from the front first, so that a chill seemed to spread down the corridor" (Rowling, 1999), a high lexical arousal-span is produced by the contrast between the low arous-

al of "silence" and the high arousal of "chill", whereas the mean lexical arousal of the whole sentence would be rather moderate;

3) The supra-lexical level, represented by subjective valence and arousal ratings for whole passages. Specific supra-lexical emotion potential may go beyond what lexical values alone would predict: e.g., the passage "Ginny glanced round, grinning, winked at Harry, then quickly faced the front again. Harry's mind wandered a long way from the marquee, back to afternoons spent alone with Ginny in lonely parts of the school grounds." (Rowling, 2007) was rated as positive, while its mean lexical valence was neutral. The emotional impact probably results from the drift of Harry's mind into the past remembering his relationship with Ginny, that the reader is rather invited to imagine than actually being told about.

Table 2.1. Examples of Passages with High Mean Lexical Valence/Arousal and Valence-/Arousal-span values

Passages	Lexical Valence	Lexical Arousal	Valence-span	Arousal-span
Highly positive mean lexical valence				
But James merely laughed, permitted his mother to kiss him, gave his father a fleeting hug, then leapt on to the rapidly filling train. They saw him wave, then sprint away up the corridor to find his friends. (Book 7)	1.74	2.67	2.30	2.07
Highly negative mean lexical valence				
'You disgusting little Squib, you filthy little blood traitor!' roared Gaunt, losing control, and his hands closed around his daughter's throat. Both Harry and Ogden yelled 'No!' at the same time. (Book 6)	-0.81	3.13	3.82	2.54
High mean lexical arousal				
Wormtail screamed, screamed as though every nerve in his body was on fire, the screaming filled Harry's ears as the scar on his forehead seared with pain; he was yelling, too. (Book 4)	-0.69	3.57	3.64	2.23
Large valence-span				
When the Dementors approached him, he heard the last moments of his mother's life, her attempts to protect him, Harry, from Lord Voldemort, and Voldemort's laughter before he murdered her.... Harry dozed fitfully, sinking into dreams full of clammy, rotted hands and petrified pleading. (Book 3)	0.11	2.95	4.60	2.35
Large arousal-span				
And then a silence fell over the crowd, from the front first, so that a chill seemed to spread down the corridor. The Fat Lady had vanished from the portrait, which had been slashed so viciously that strips of canvas littered the floor; great chunks of it had been torn away completely. (Book 3)	-0.015	2.76	3.40	2.83

As a main hypothesis, we expect lexical variables to significantly predict subjective ratings and BOLD responses in emotion-related brain areas, therefore corroborating the approach of Bestgen (1994) and Whissell (2003b), i.e., the prediction of the affective impact of text units from mean lexical valence and arousal values. Furthermore, we expect lexical variables' effects on BOLD responses to be, at first glance, largely comparable to those of subjective ratings of the whole text passages. However, we also hypothesize that our data might reveal discernable effects of emotion potential at lexical and supra-lexical levels: In the usage of language, we can employ different words to express the same thing, and the specific choice of our words has a huge impact on how our message will be received at the affective level. Thus, it makes a difference whether we say: "why don't you clean up your *mess* vs. *thing* behind you?", or whether we call a person living on the street a "*homeless*" or a "*bum*". In this case, lexical affective variables could produce emotional effects beyond the ones obtained for subjective ratings of entire text units, because the latter ones might lose focus on fine-grained emotional connotations at the lexical level when trying to evaluate complex parts of text as a whole.

In addition, the automatic attention-capture potential of emotion-laden words can override integration processes involved in discourse comprehension by ensuring their processing prioritization relative to the context. Therefore, we expected to find significant lexical effects after partialling out the variance accounted for by passage ratings, in particular in the "salience network" (Lindquist et al., 2012; Seeley et al., 2007).

Furthermore, specific lexical effects may not be limited to single words' salience alone: all words we encounter embedded in a sentence have already been seen or heard previously from us in many other and potentially very different contexts. All of these contribute to the complex pattern of emotional connotations a single word can have in our memory, which has the potential to "project" affective processes triggered by single words via associative links far beyond the given context of a sentence – which is another reason to expect lexical effects to be at least somewhat independent from more general text evaluations.

Finally, after partialling out the variance accounted for by affective lexical variables first, we might expect rating values to correlate with activation in areas associated with emotional conceptualization, evaluation (Lindquist et al., 2012), and the ToM network (Mar, 2011), which are supposed to represent the specific emotion potential of supra-lexical units (e.g., Bohrn, Altmann, & Jacobs, 2012).

2.2. Materials and Methods

2.2.1 Participants

Twenty-four right-handed native German speakers (16 women) gave written consent to take part in the experiment, which was approved of by the ethics committee of the Freie Universität Berlin. Their age ranged from 18 to 31 years (mean ± *SD* = 23.71 ± 3.67). All participants had read at least one Harry Potter book, and were therefore familiar with its context enough to understand the novel-specific contents. They all had normal or corrected-to-normal vision, and reported no neurological or psychiatric disorders. Participants were compensated properly monetarily or with course credits for their participation.

2.2.2 Stimuli

To prepare our stimulus material we screened all seven HP novels (Rowling, 1997, 1998, 1999, 2000, 2003, 2005; 2007, German translations by Klaus Fritz, Carlsen Verlag, Hamburg) for text passages featuring either particularly emotional or neutral moments or events. We finally selected 120 passages, each of which was 4 lines long. The passages provide a wide range of valence and arousal as demonstrated in two other studies (Chapter 3 & 5). Passage selection further ensured that: 1) comprehension of the passages did not require a high level of familiarity with Harry Potter novels; 2) the emotional connotations of the passages clearly emerged at their very beginning; 3) emotional contents were unambiguous and generally consistent throughout the passage.

2.2.3 Design

The 120 text passages were divided into two subsets of 60. During the experiment, each participant read one subset in German and the other one in English. Each subset was presented to 12 participants in German and English respectively. Only the data for reading in German was used for analyses in this study (see Chapter 5 for analyses of the complete data following a bilingualism research question).

2.2.4 Procedure

The experiment consisted of four runs, each containing 15 German and 15 English passages. The order of presentation was pseudo-randomized so that the distribution of language switch positions was balanced in each run and across all participants. Similar to the design of a previously successful fMRI experiment on text-reading (Altmann et al., 2012), each passage was presented for 14 s in the MR scanner, distributed on 4 lines (shown consecutively for 3.5 s each), and then followed by 14 s of fixation cross. The visual input was presented on a computer screen and was reflected to the participants' eyes via a mirror.

To make sure that participants were attentive and actively comprehended the passages, they had been informed that several (leaving open how many) randomly selected passages in each run were immediately followed by a context-specific yes/no question, unrelated to emotion (e.g., 'Was Harry in a train station?' 'Was the alarm clock broken again?'), to which participants responded via button press.

2.2.5 fMRI data acquisition

Functional data were acquired on a Siemens Tim Trio 3T MR scanner. Four runs of 440 volumes were measured using a T_2^*-weighted echo-planar sequence [slice thickness: 3 mm, no gap, 37 slices, repetition time (TR): 2s, echo time (TE): 30ms, flip angle: 70°, matrix: 64 × 64, field of view (FOV): 192 mm, voxel size: 3.0 mm × 3.0 mm × 3.0 mm] and individual high-resolution T1- weighted anatomical data (MPRAGE sequence) were acquired (TR: 1.9, TE: 2.52, FOV: 256, matrix: 256 × 256, sagittal plane, slice thickness: 1 mm, 176 slices, resolution: 1.0 mm × 1.0 mm × 1.0 mm).

2.2.6 Post-scan ratings, affective lexical variables, and correlational analyses

Following the experiment in the MR scanner, participants rated all 120 passages in the language version they had read inside the scanner on valence, scaled from -3 (very negative) to +3 (very positive, see Võ et al., 2006), and arousal, scaled from 1 (very calming) to 5 (very arousing, see Bradley & Lang, 1999; Schmidtke, Schröder, et al., 2014; Võ et al., 2009; Võ et al., 2006). For each passage, we calculated affective lexical variables based on valence and arousal values provided by a large scale German normative database for lemma forms of single words contained in the passages (Conrad et al., in prep., see also BAWL-R, Võ et al., 2009, and ANGST, Schmidtke et al., 2014). Note that this database containing normative affective rating values for over 6,600 German lemmata provided matches for overall 54% of content words of our stimulus material. Based on these values we computed the following affective lexical variables for all of our text passages stimuli: 1) mean lexical valence, 2) mean lexical arousal, 3) lexical valence-span and 4) lexical arousal-span. Bivariate and partial correlations between affective lexical variables and mean values of valence and arousal ratings for each passage are given in

Table 1. Note that, although mean rating values positively correlated with lexical values, respective correlations were not too large (<0.6 in all cases); this leaves open the possibility to obtain differential effects for ratings by partialling out shared variance with lexical values, or vice versa, on brain activation.

2.2.7 fMRI preprocessing

The fMRI data were preprocessed and analyzed using the software package SPM8 (www.fil.ion.ucl.ac.uk/spm). Preprocessing consisted of slice-timing correction, realignment for motion correction, and sequential coregistration. Structural images were segmented into grey matter, white matter, cerebrospinal fluid, bone, soft tissue, and air/background with the 'New Segment' module (Ashburner & Friston, 2005). A group anatomical template was created with DARTEL (Diffeomorphic Anatomical Registration using Exponentiated Lie algebra, Ashburner, 2007) toolbox from the segmented grey and white matter images. Transformation parameters for structural images were then applied to functional images to normalize them to the brain template of the Montreal Neurological Institute (MNI) supplied with SPM. For the univariate analysis, functional images were resampled to a resolution of 1.5 × 1.5 × 1.5 mm, and spatially smoothed with a kernel of 6 mm full-width-at-half-maximum during normalization.

Reg.	Model 1	Model 2	Model 3
1	German Reading Condition		
2	L. Arousal	Arousal R.	Arousal R.
3	L. Val. 1st	Val. R. 1st	Val. R. 1st
4	L. Val. 2nd	Val. R. 2nd	Val. R. 2nd
5	Aro.-span	Aro.-span	L. Arousal
6	Val.-span	Val.-span	L. Val. 1st
7	Arousal R.	L. Arousal	L. Val. 2nd
8	Val. R. 1st	L. Val. 1st	Aro.-span
9	Val. R. 2nd	L. Val. 2nd	Val.-span
10	English Reading Condition		
11	Questions		
12-17	Six motion parameters		

Serial Orthogonalization

Figure 2.1. The Design Matrices of Three Models of Parametric Analyses

Each model contains the regressors of the German Reading condition, six parametric modulators and their polynomial expansions, English Reading, and Question conditions, followed by six motion parameters. All regressors are serially orthogonalized. Three models differ in their sequence of entry of the parametric modulators. L. Arousal = lexical arousal mean; L. Val. 1st = first order lexical valence mean; L. Val 2nd = second order lexical valence mean; Aro.-span = arousal-span; Val.-span = valence-span; Arousal R. = arousal ratings; Val. R. 1st = first order valence ratings; Val. R. 2nd = second order valence ratings.

2.2.8 fMRI analyses

We calculated statistical parametric maps by multiple regressions of the data onto a model of the hemodynamic response (Friston et al., 1995). In this study, we tried to disentangle specific or potentially differential influences of emotion potential at lexical and supra-lexical levels on brain activation using three different models of parametric modulation (see Fig. 2.1): all models contained two regressors for German and English conditions, and each passage lasted 14 seconds. Six parametric modulators and their polynomial expansions (detailed below for each model separately) were added after the German condition. The context-specific questions were modeled as the third condition, and each question lasted four seconds. The six realignment parameters were modeled as six additional regressors. Regressors were convolved with the canonical hemodynamic response function in SPM8.

In all models, parametric modulators (predictors) and their second-order derivatives were serially orthogonalized from the first to the last one, in a Gram-Schmidt process (Büchel, Holmes, Rees, & Friston, 1998; Büchel, Wise, Mummery, Poline, & Friston, 1996; Golub & Van Loan, 1996) by SPM8. Note that, despite orthogonalization, first order effects (i.e., effects of the first predictors entered in the model), potentially include shared variance that cannot be uniquely attributed to any of the lexical, inter-lexical, or supra-lexical variables. On the other hand, effects of the last predictors entered in the model represent differential effects specific to those predictors, i.e., variance that could be uniquely attributed to a specific level, since all shared variance has already been partialled out by previously entered predictors. The current study, thus, uses conservative inferences concerning differential effects specific to each level of text processing.

In Model 1, six predictors were entered in the following order (see Fig. 2.1): 1) linear lexical arousal mean; 2) linear and quadratic lexical valence mean; 3) linear arousal-span; 4) linear valence-span; 5) linear arousal ratings; 6) linear and quadratic valence ratings. This model reveals first order effects of affective lexical variables and differential, or unique, effects of subjective passage ratings – after partialling out variance shared with affective lexical variables.

In Model 2, the order of entry was: passage ratings (predictor 1 & 2), arousal- and valence-span (predictor 3 & 4), and lexical means (predictor 5 & 6). This model focused on the differential effects of lexical means after partialling out variance due to subjective passage ratings and lexical arousal- and valence-span.

In Model 3, arousal- and valence-span (predictor 5 & 6) were entered after lexical means (predictor 3 & 4) and passage ratings (predictor 1 & 2). Therefore, this model focused in particular on differential effects specific to lexical arousal- and valence-span.
To explore the effect of reading vs. fixation at the group level, beta-images of the contrast [German reading > fixation] from each participant were entered into a random effect, one-sample t-test. For each parametric effect at the group level, beta-images of each polynomial expansion of each parametric modulator were taken from each participant and entered into random effect, one-sample t-tests.

We calculated correlations with both first and second order polynomial expansions (Büchel et al., 1998; Büchel et al., 1996) for the valence dimension because 1) valence is a bipolar variable; and 2) a meta-analysis on emotion studies suggested that some emotion-related structures, like amygdala and pregenual anterior cingulate cortex (ACC), would respond to bipolar emotional valence of the passages, possibly in a quadratic fashion (e.g., Lewis et al., 2007); 3) according to Lewis et al. (2007), both arousal and quadratic valence code for a generalized form of "salience", by directing attention toward behaviorally important goals (Cunningham et al., 2004; Winston et al., 2003). Results from Recio et al. (2014) indicate that valence and arousal contribute independently to early attentional stages of word processing. In line with these findings, while the second order of valence ratings for our stimuli strongly correlates with arousal ratings (r = 0.54), quadratic mean lexical valence is quite independent of mean lexical arousal (r = -0.18; Table 2.2). All this justifies using both first and second order valence and arousal values as predictors for our models in order to explore their potentially independent contributions to brain activations. We always entered arousal before valence variables into our models in order not to exclude potential arousal effects, given that valence already enters in both linear and quadratic fashions. In this way, variance attributed to quadratic valence is not attributable to arousal.

Table 2.2. Bivariate Correlations and partial Correlations (in the parenthesis) between the Ratings and affective lexical Parameters

	Quad. Val. Rating	Arousal Rating	Lexical Valence	Quad. Lex. Valence	Lexical Arousal	Valence-span	Arousal-span
Valence Rating	-0.19 (0.28)	-0.72* (-0.63*)	0.53* (0.21)	0.38 (-0.06)	-0.38* (0.11)	-0.37*(-0.08)	-0.49* (0.01)
Quad. Val. Rat.		0.54* (0.38*)	-0.15 (0.16)	-0.08 (-0.06)	0.50* (0.23)	0.48* (0.17)	0.47* (0.10)
Arousal Rating			-0.48* (0.03)	-0.32* (-0.04)	0.59* (0.20)	0.52*(-0.01)	0.66* (0.27)
Lexical Valence				0.79* (0.81*)	-0.49* (-0.54*)	-0.34*(0.26)	-0.47* (-0.17)
Quad. Lex. Val.					-0.18 (0.47*)	-0.35*(-0.33*)	-0.32 (0.11)
Lexical Arousal						0.49*(0.26)	0.53* (-0.06)
Valence-span							0.62*(0.38*)

* 2-tailed pairwise p < .0033, the Bonferroni-corrected significance threshold for 15 tests

**Abbreviation: Quad = quadratic; Val. = valence; Lex. = lexical; Rat. = rating

None of the affective lexical variables or subjective passage ratings showed significant correlations with passage length (all *p*s > 0.1), operationalized in numbers of letters and words, passage-wise average word imageability taken from the BAWL-R (Võ et al., 2009) and the ANGST (Schmidtke, Schröder, et al., 2014) databases, or passage-wise average log frequency of words given in the Leipzig Wortschatz Lexicon (available at http://wortschatz.uni-leipzig.de/). Therefore, no confound of affective dimensions with length, frequency, or imageability seems to be present in our material and we did not use these variables as additional predictors in order not to inflate our models.

The fMRI analyses were conducted at the whole brain level. Furthermore, because current meta-analyses strongly suggested the amygdala to be involved in emotion processing (Costafreda et al., 2008; Lindquist et al., 2012; Murphy et al., 2003; Phan et al., 2002), especially in emotional discourse comprehension (Ferstl et al., 2005), we performed small volume correction (SVC) with a bilateral amygdala mask for contrasts showing parametric emotion effects. The bilateral amygdala mask in the MNI template was defined by the WFU Pickatlas Tool (Maldjian, Laurienti, Kraft, & Burdette, 2003). For the one-sample t-test showing the effect of reading vs. fixation, we used the voxel-level family-wise error (FWE) corrected $p < 0.05$ and cluster threshold of 5 to report only very strong activation differences. For the parametric analyses at the whole brain level, we used an initial voxel-level threshold of uncorrected $p < 0.005$, then a cluster-level threshold of false discovery rate (FDR) corrected $p < 0.05$ for the entire image volume, as suggested by Liebermann and Cunningham (2009) for studies in cognitive, social and affective neuroscience. For the SVC analyses of the amygdala, we used initial voxel-level threshold of uncorrected $p < 0.005$ for the entire image volume, then the threshold of voxel-level FWE corrected $p < 0.05$ after applying the SVC with a bilateral amygdala mask. The labels reported were taken from the 'TD Labels' (Lancaster et al., 1997; Lancaster et al., 2000) or 'aal' labels in the WFU Pickatlas Tool. The Brodmann areas (BA) were further checked with the Talairach Client using nearest grey matter search after coordinate transformation with the WFU Pickatlas Tool.

2.3. Results and discussion

As our results involve a large amount of data for different statistical models, we will briefly discuss results of each of the following subsections before moving to the next set of results to enhance comprehensibility of the entire report.

2.3.1 Behavioral data

2.3.1.1. Task performance

We randomly inserted four context-specific questions in each run, i.e., 16 questions throughout the experiment. All participants correctly responded to questions in the scanner above chance (≥ 62.5%) with overall mean accuracy of 81.47% ± 13.16% suggesting good comprehension of the presented text passages.

2.3.1.2. Correlations between affective lexical variables and ratings

Correlations and partial correlations between ratings and lexical parameters are listed in Table 2.2, indicating that mean lexical valence values (taken from Conrad et al., in prep.) accounted for 28% of the variance in the valence ratings of text passages, while the mean lexical arousal values accounted for about 35% of the variance of arousal ratings. Surprisingly, while lexical arousal-span showed a significant positive correlation with mean lexical arousal values and lexical valence-span, it accounted for even more of the variance of the arousal ratings ($r^2 = 0.44$) than did mean lexical arousal values ($r^2 = 0.35$) and valence-span ($r^2 = 0.27$). Because of the high intercorrelations of the affective lexical variables, we calculated partial correlations to remove joint variance. These showed significant correlations between mean lexical valence and valence ratings ($r = 0.34$, $p < 0.001$), between mean lexical arousal and arousal ratings ($r = 0.36$, $p < 0.001$), and between lexical arousal-span and arousal ratings ($r = 0.40$, $p < 0.001$).

Taken together, these results partially support the hypothesis that a lexical measure of single words' mean emotion potential – as estimated by standard databases – significantly contributes to the subjective emotional reading experience (cf. Bestgen, 1994; Jacobs, 2014). Importantly, our data also show that, at the behavioral level, lexical mean values alone are not sufficient to predict all aspects of affective impact at the text level: lexical means neglect the emotion potential of dynamic changes of lexical values across a text – as assessed by our valence- and arousal-span measures. More specifically, the latter ones explained additional variance of passage arousal ratings as hypothesized by the neurocognitive poetics model of literary reading (Jacobs, 2014).

2.3.2. fMRI data

2.3.2.1 reading (German) vs. fixation

Results are summarized in Table 2.3 and shown in Figure 2.2. Clusters more active in the reading condition included bilateral inferior prefrontal gyrus, dorsolateral prefrontal cortex (dlPFC), vmPFC, medial supplementary motor area (SMA), visual cortex, precuneus, superior temporal sulcus (STS), temporo-parietal junction (TPJ), thalamus, amygdala, pons, and cerebellum.

The simple contrast between reading German passages vs. fixation showed extensive activation of the ELN (Ferstl et al., 2008), in line with previous studies of text comprehension. Bilateral STS, IFG, and medial supplementary motor area are associated with language processing (Price, 2012); dlPFC, TPJ, anterior temporal lobe (aTL), precuneus, and amygdala are associated with ToM or affective empathy processing (Mar, 2011; Walter, 2012), whereas aTL and vmPFC are associated with multimodal (semantic) integration and emotional conceptualization (Binder & Desai, 2011; Binder et al., 2009; Lindquist et al., 2012). Finally, significant activation peaks in bilateral amygdala, vmPFC, and pons are in line with previous findings from Ferstl et al. (2005), during presentation of emotion-laden texts. The results clearly suggest that our participants read the texts by connecting sentences, producing inferences and keeping previously-read information in the working memory, rather than just picking up emotion-laden words, as if those were presented in isolation. Note that such elaborate, comprehension processing is further supported by different analyses of our data showing activation differences for passages describing events that violate participants' world knowledge (Chapter 4).

Table 2.3 Main Effects of Reading (German) vs. Fixation

H	Regions	Cluster size	p*	T	B.A.	[x, y, z]
Reading (German) > Fixation						
L+R	Thalamus, PHC incl. L Amygdala	3447	<.001	20.39		22 -27 -0
			<.001	14.91		-21 -30 -0
			<.001	11.93		-28 -6 -21
L	STS incl. aTL (STG & MTG)	3992	<.001	17.07	38	-51 11 -14
			<.001	15.00	22	-57 -3 -9
			<.001	14.01	22	-54 -39 4
L+R	Cerebellum & Lingual gyrus	13379	<.001	16.83		30 -64 -50
			<.001	15.15	17	-12 -97 -6
			<.001	14.90	17	16 -87 -3
R	STS incl. aTL (STG & MTG)	2714	<.001	16.46	41	51 -21 -8
			<.001	14.58	22	50 -27 -0
			<.001	14.31	21	54 -9 -14
L	SMA (SFG)	676	<.001	14.99	6	-3 2 67
			<.001	10.33	6	0 3 60
			0.002	8.68	6	-4 9 63

L	Cerebellar Nodule & Tonsil	1083	<.001	13.77		-2 -55 -35
			<.001	12.57		-20 -40 -44
			0.001	8.92		-9 -49 -41
R	PHC incl. Hippocampus & Amygdala	380	<.001	12.69		33 -1 -20
			<.001	12.11		30 -10 -20
			<.001	9.49	34	21 -10 -18
L	Precentral gyrus	822	<.001	12.31	6	-51 -1 48
			<.001	10.68	4	-50 -12 43
			0.002	8.82	6	-46 -6 37
R	Cerebellar Declive	316	<.001	12.27		42 -66 -24
			<.001	10.97		33 -61 -26
L	IFG pars triangularis	277	<.001	11.81	47	-50 27 -2
R	Cerebellar Tonsil	107	<.001	10.58		21 -43 -44
R	Precentral & MFG	168	<.001	10.02	6	60 -7 42
			0.003	8.35	6	51 5 49
L+R	Pons	71	<.001	9.94		0 -36 -39
L	Pons	45	<.001	9.49		-6 -25 -38
L	Putamen	195	0.001	9.15		-20 5 7
R	Postcentral gyrus	18	0.001	9.10	3	51 -18 55
R	IFG pars triangularis & MFG	202	0.001	8.86	46	56 33 9
			0.012	7.66	45	57 27 3
L	IFG pars triangularis & MFG	191	0.002	8.80	46	-42 17 22
R	Paracentral lobule	45	0.002	8.76	6	9 -33 58
R	Precentral gyrus	27	0.004	8.31	6	30 -19 66
L	Paracentral lobule	24	0.004	8.23	6	-8 -34 57
R	DLPFC (MFG)	129	0.005	8.14	9	41 9 30
			0.007	7.90	46	41 20 25
R	Precentral gyrus	11	0.005	8.09	6	28 -19 55
R	Caudate tail	7	0.006	7.99		22 -31 21
L+R	vmPFC (Orbital gyrus)	22	0.006	7.98	11	0 48 -18
L	Cuneus	59	0.007	7.95	18	-21 -81 19
R	Cingulate	18	0.007	7.94	31	12 -24 48
R	ITG	13	0.008	7.85	37	50 -49 -12
R	TPJ (MTG)	79	0.008	7.84	39	32 -67 28
L	TPJ (IPL)	37	0.010	7.75	40	-26 -49 52
R	Precentral gyrus	8	0.011	7.70	6	36 -10 63
R	Precuneus	11	0.011	7.70	7	30 -55 51
R	Caudate body	15	0.014	7.54		8 9 10
R	Fusiform	8	0.018	7.40	37	38 -43 -17
L	Fusiform	9	0.021	7.33	20	-39 -12 -30

* Voxel level FWE-corrected

Abbreviations: aTL = anterior temporal lobe; dlPFC = dorsolateral prefrontal cortex; IFG = inferior frontal gyrus; ITG = inferior temporal gyrus; MFG = middle frontal gyrus; MTG = middle temporal gyrus; PHC = parahippocampal cortex; SMA = supplementary motor area; STG = superior temporal gyrus; STS = superior temporal sulcus; TPJ = temporo-parietal junction; vmPFC = ventromedial prefrontal cortex; H = hemisphere; L = left; R = right; p = p-value; T = T-value; B.A. = Brodmann area; x, y, z = MNI coordinates

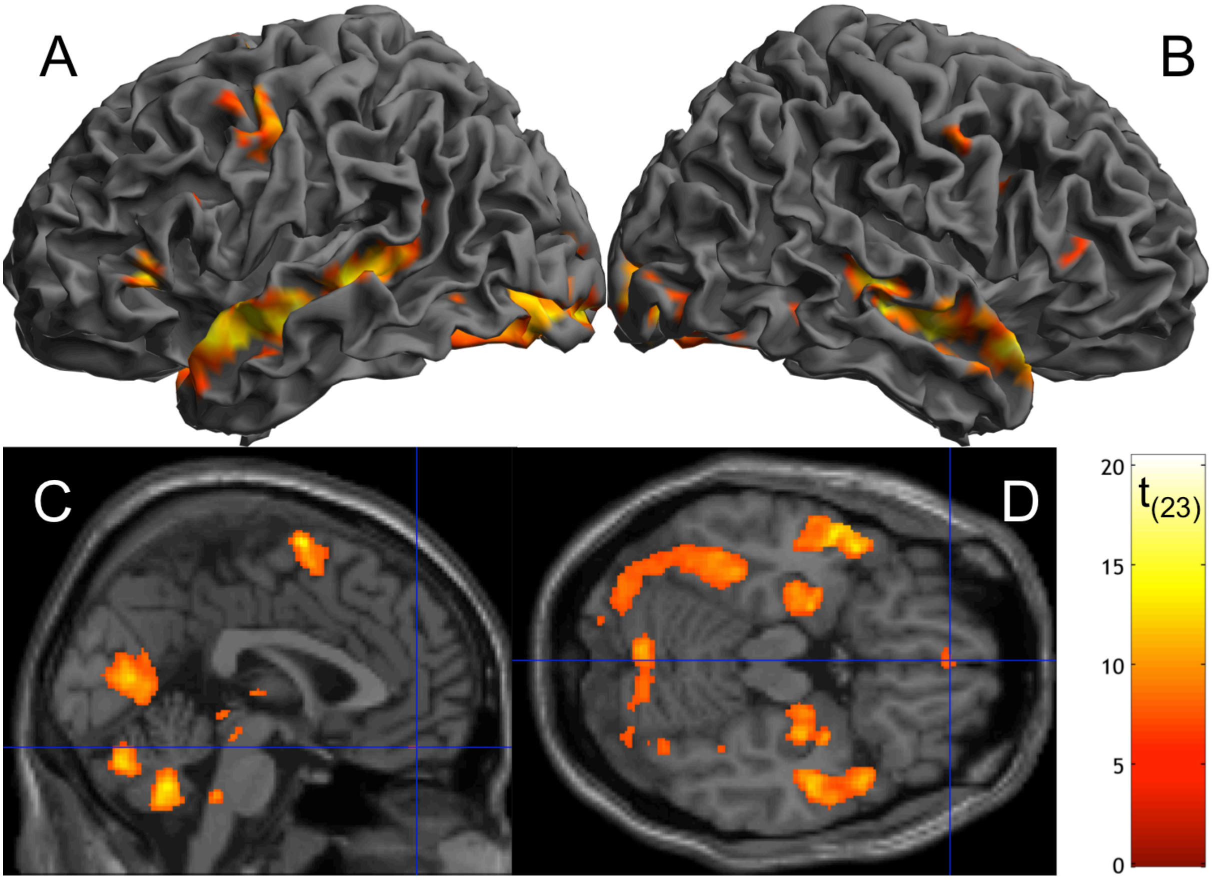

Figure 2.2. Results of Reading (German) vs. Fixation

Regions showing significantly stronger BOLD response in the German reading condition than fixation. The voxel-level threshold is FWE corrected $p < 0.05$, the size threshold 5.

A: left hemisphere render image.

B: right hemisphere render image.

C: sagittal section at $x = 0$ showing activation in medial supplementary motor cortex, visual cortex, and pons.

D: transverse section at $z = -18$. The crosshair highlights ventromedial prefrontal cortex (0 48 -18). The section also shows activation in bilateral anterior temporal lobe and parahippocampal cortex including amygdala.

2.3.2.2. Unspecific effects at the lexical, intra-lexical and supra-lexical levels: first order effects in different models

2.3.2.2.1. Model 1: unspecific effects of mean lexical arousal

When lexical arousal was entered as the first predictor into the model, hemodynamic responses in the following neural substrates increased significantly when reading passages with higher mean lexical arousal (Fig. 2.3, panel A-C in red color; Table 2.4): bilateral middle superior temporal sulcus (STS, BA 21, 22 & 41), bilateral caudate tail, left IPL and supramarginal gyrus (SMG, BA 40), left primary visual cortex (BA 17) and PCC (BA 30), right cerebellum, and after SVC, bilateral amygdala (Fig. 2.3, panel D).

Hemodynamic responses in the following neural substrates decreased significantly when reading passages with higher mean lexical arousal (Fig. 2.3, panel A-C in green color; Table 2.4): bilateral parahippocampal cortex (PHC, BA 28 & 36, including left hippocampus), bilateral anterior cingulate cortex (ACC, BA 32 & 25) and vmPFC (BA 10 & 11), bilateral dorsolateral prefrontal cortex (dlPFC, BA 8), bilateral middle superior temporal gyrus (STG), right anterior temporal lobe (aTL, BA 20 & 21), right posterior cingulate cortex (PCC, BA 23, 30 & 31), right medial premotor cortex (BA 6), right medial frontopolar cortex (BA 10), right TPJ (BA 19 & 39), left precuneus (BA 19), and left cerebellum.

Table 2.4. Unspecific Effects of mean affective lexical Values in Model 1

H	**Regions**	**Cluster size**	**p***	**T**	**B.A.**	***[x, y, z]***
Positive linear Correlation with lexical Arousal						
L	Cuneus & PCC	337	0.033	5.76	17/30	-18 -76 9
R	STS (STG & MTG)	526	0.009	5.34	22	50 -30 -3
R	Cerebellum	614	0.009	5.30		15 -78 -30
L	IPL, supramarginal & postcentral gyrus	474	0.011	5.06	40/2	-52 -37 34
L	Caudate tail, hippocampus & putamen	521	0.009	4.97		-33 -24 -6
L	MTG & STG	520	0.009	4.96	22/41/21	-51 -36 4
R	Caudate tail	372	0.025	4.81		22 -28 21
R	Amygdala (SVC)	35	0.015	4.41		27 -9 -17
L	Amygdala (SVC)	35	0.028	4.09		-26 -6 -23
Negative linear Correlation with lexical Arousal						
L	Precuneus, SPL & cerebellum	1827	<.001	7.60	19/7	-42 -79 34
R+L	ACC, vmPFC (subcallosal gyrus	1873	<.001	6.94	32	8 38 -9
	& med FG)			4.99	25/11	-6 24 -12
R	TPJ (IPL, MTG & AG)	3405	<.001	6.44	19/39	42 -73 37
R	PHC & hippocampus	1000	<.001	6.37	28	30 -34 -12
R	dlPFC (MFG & SFG)	2371	<.001	6.16	8	39 27 49

L	PHC	714	0.001	6.11	36/28	-24	-39	-15
R	PCC	1586	<.001	6.02	23/30	6	-60	18
R	PCC	1575	<.001	5.88	31	9	-42	39
L	STG & postcentral gyrus	562	0.002	4.82	22/42/41	-57	-9	3
R	aTL (MTG & ITG)	477	0.005	4.73	20/21	50	-6	-23
L	dlPFC (MFG)	342	0.019	4.57	8	-28	32	51
R	STG & precentral gyrus	507	0.004	4.41	22/44	53	-1	1
R+L	Medial premotor cortex (medial FG) & cingulate gyrus	327	0.021	4.37	6	15	-3	60
				3.35	24	-6	-6	52
R+L	SFG & medial FG	252	0.039	4.15	10	12	59	1
				3.69	10	-6	65	7
L	Cerebellum	272	0.039	4.15		-50	-67	-35
Positive linear Correlation with lexical Valence								
R	aTL (MTG & STG)	2088	<.001	5.86	38/22/21	51	10	-18
L	aTL (MTG & STG)	2207	<.001	5.66	21/22	-50	6	-26
L	Premotor cortex (SFG)	423	0.009	5.66	6	-8	6	67
R	Cerebellum	394	0.011	5.23		24	-85	-38
R	Lingual gyrus & cuneus	1317	<.001	5.06	18/30	21	-85	-9
L	dlPFC (SFG)	499	0.004	4.87	9/8	-20	42	43
L	TPJ (MTG, IPL & supramarginal gyrus)	767	<.001	4.68	39/13	-44	-60	24
L	PHC & lingual gyrus	278	0.043	4.49	30/19	-21	-55	1
L	PCC & precuneus	717	<.001	4.14	31/7	-3	-63	24
Negative linear Correlation with lexical Valence								
L	MTG	1163	<.001	6.27	37	-54	-57	-2
L	Postcentral gyrus & IPL	661	0.001	5.41	2/40	-60	-33	42
Positive quadratic Correlation with lexical Valence								
R	SPL & caudate tail	994	<.001	4.67	7	34	-57	51
L	Caudate tail	804	<.001	4.58		-14	-39	18
Negative quadratic Correlation with lexical Valence								
R	STS (MTG & STG)	1131	<.001	5.71	21/22	51	-1	-15
L	STG, MTG & ITG	1369	<.001	5.59	22/20/38	-63	-25	3
L	TOJ (MTG & cuneus)	4912	<.001	5.53	39/18	-48	-66	25
L	TOJ (PHC, fusiform & lingual gyrus)	863	<.001	5.03	36/20/19	-26	-43	-11
L+R	PCC & precuneus	963	<.001	4.86	30/31	-12	-63	13
				4.15	31	8	-63	18
L	Frontopolar cortex (SFG, med. FG)	588	0.003	3.94	10/9	-12	63	10

* Cluster level FDR-corrected for the whole brain; voxel-level FWE-corrected for SVC

Abbreviations: ACC = anterior cingulate cortex; AG = angular gyrus; aTL = anterior temporal lobe; dlPFC = dorsolateral prefrontal cortex; FG = frontal gyrus; IFG = inferior frontal gyrus; IPL = inferior parietal lobule; ITG = inferior temporal gyrus; MFG = middle frontal gyrus; MTG = middle temporal gyrus; PCC = posterior cingulate cortex; PHC = parahippocampal cortex; SFG = superior frontal gyrus; SPL = superior parietal lobule; STG = superior temporal gyrus; STS = superior temporal sulcus; SVC = small volume correction; TOJ = temporo-occipital junction; TPJ = temporo-parietal junction; vmPFC = ventromedial prefrontal cortex; H = hemisphere; L = left; R = right; p = p-value; T = T-value; B.A. = Brodmann area; x, y, z = MNI coordinates

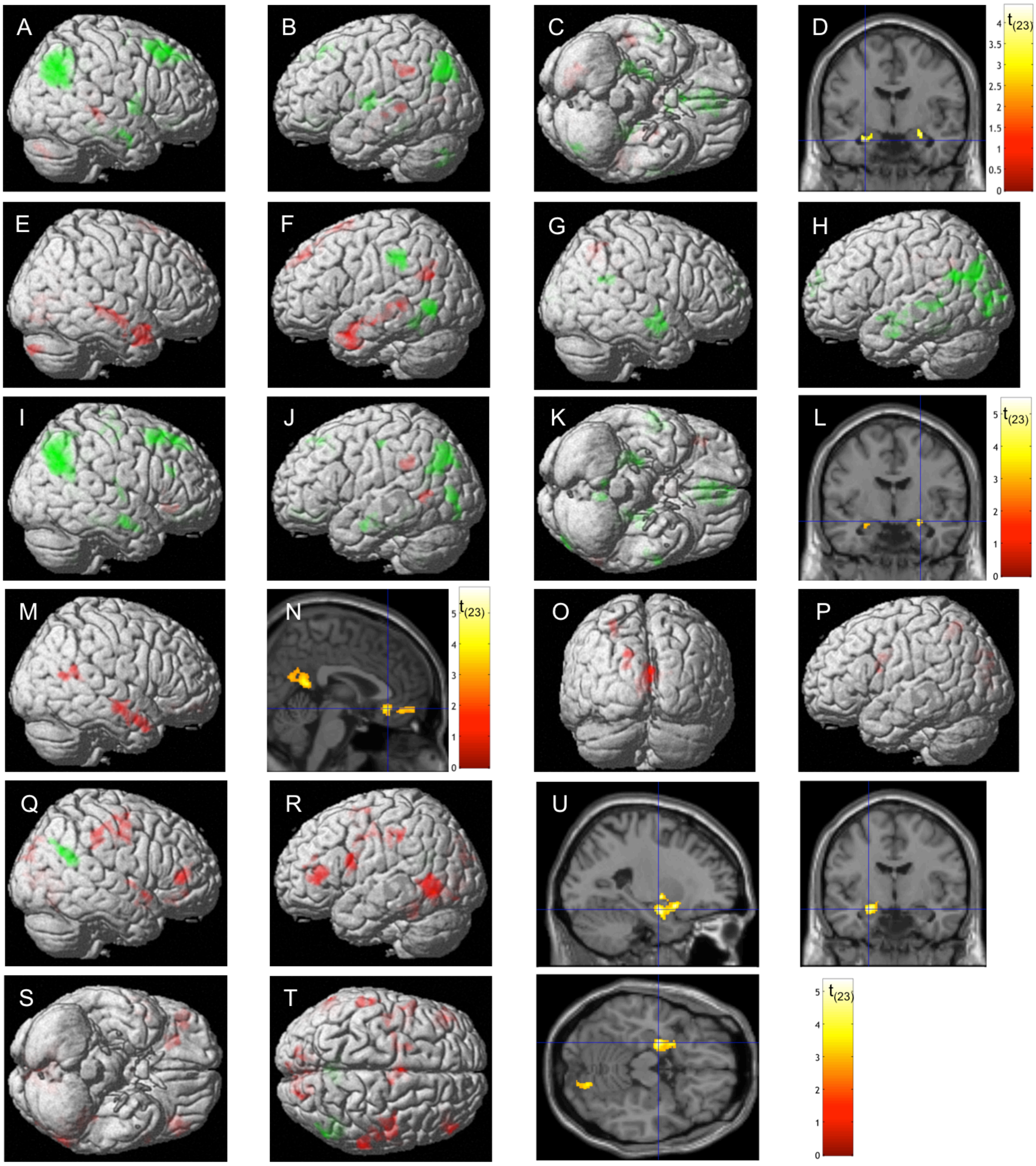
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Figure 2.3 Unspecific Effects of Affective Lexical Variables

Render images were produced with xjview, in which red color indicates significant positive correlations; green indicate significant negative correlations.

Panel A to D show unspecific effects of *mean lexical arousal* in Model 1. Panel D shows significant positive correlation in bilateral amygdala (crosshair -26 -6 -23) after SVC.

Panel E and F show unspecific linear effects, and panel G and H show unspecific quadratic effects of *mean lexical valence* in Model 1.

Panel I to K show unspecific effects of *arousal ratings* in Model 1.

Panel M and N show unspecific linear effects, and panel L, O and P show unspecific quadratic effects of *valence ratings* in Model 2. Panel L shows significant positive quadratic correlation with *valence ratings* in bilateral amygdala (crosshair 27 -6 -14) after SVC.

Panel Q to T: unspecific effects of *arousal-span* in Model 1.

Panel U: unspecific effects *valence-span* in Model 1 highlighting significant positive correlation in the left amygdala (crosshair -24 -7 -17).

The initial voxel-level threshold is uncorrected $p < 0.005$, the size threshold is according to the cluster-level FDR correction in each analysis.

2.3.2.2.2. Model 1: unspecific effects of mean lexical valence

After partialling out variance due to mean lexical arousal, brain activity in the following regions significantly increased with more positive mean lexical valence of passages (Fig. 2.3, panel E & F in red color; Table 2.4): bilateral aTL (BA 21, 22 & 38), left premotor cortex (BA 6), left dlPFC (BA 8 & 9), left TPJ (BA 39), left PHC (BA 30), left PCC & precuneus (BA 31 & 7), right extrastriate visual cortex (BA 18 & 30), and right cerebellum.

Hemodynamic responses in left posterior middle temporal gyrus (MTG, BA 37) and left IPL (BA 40) decreased significantly with more positive mean lexical valence (Fig. 2.3, panel E & F in green color; Table 2.4).

BOLD responses in bilateral caudate tail and right superior parietal lobule increased quadratically when reading passages with either positive or negative mean lexical valence (Fig. 2.3, panel G in red color; Table 2.4), while in the following regions the BOLD responses decreased quadratically with mean lexical valence (Fig. A.1, panel G & H in green color; Table 2.4): right middle STS (BA 21 & 22), left posterior temporal cortex (BA 20, 22 & 38), left temporo-occipital junction (TOJ, one cluster in BA 39 & 18, another cluster in BA 36, 20 & 19), bilateral PCC and precuneus (BA 30 & 31), and left frontopolar cortex (BA 9 & 10).

2.3.2.2.3. Model 1: unspecific effects of lexical arousal-span

After partialling out variance due to mean lexical arousal and valence, we found significant positive correlation between BOLD responses and arousal-span in the following neural substrates (Fig. 2.3, panel Q to T in red color; Table 2.5): left inferior frontal gyrus (IFG) pars triangularis including anterior insula (BA 13, 45 & 46), left IFG pars opercularis including anterior insula (BA 9, 13 & 44), right IFG pars triangularis and orbitalis (BA 46 & 47), bilateral pre- and postcentral gyrus (BA 2, 4 & 6), bilateral posterior MTG and inferior temporal gyrus (ITG, BA 37), bilateral extrastriate cortex (BA 18, 19 & 30), left premotor cortex (two clusters, BA 6), left MTG and fusiform gyrus (BA 20 & 37), left middle cingulate gyrus (BA 24), and right middle STS (BA 21, 22 & 38).

On the other hand, there was a significant negative correlation between arousal-span and BOLD responses in bilateral PCC (BA 29 & 31) and right SMG (BA 39 & 40; Fig. 2.3, panel Q to T in green color; Table 2.5).

Table 2.5.Unspecific Effects of Arousal- and Valence-span in Model 1

H	Regions	Cluster size	p*	T	B.A.	[x, y, z]
Positive linear Correlation with Arousal-span						
L	IFG pars triangularis, insula & MFG	1034	<.001	6.97	13/45/46	-40 29 10
L	Posterior MTG & ITG	2175	<.001	5.70	37/19	-56 -63 -3
R	IFG pars triangularis and orbitalis	765	0.001	5.70	46/47	47 36 6
L+R	Cingulate, medial FG	786	0.001	5.58	24	-2 -4 49
				4.78	6/32	9 -9 60
L+R	Cuneus & Lingual gyrus	4209	<.001	5.32	18/19	10 -69 -3
				4.77	30	-2 -73 7
R	Middle STS (MTG & STG)	430	0.013	5.11	21/22/38	51 2 -14
L	IFG pars opercularis & insula	821	0.001	4.97	44/9/13	-52 8 16
R	Precentral & postcentral gyrus	1265	<.001	4.63	4/6/2	44 -15 60
L	IPL & postcentral gyrus	374	0.020	4.50	40/2	-56 -34 43
L	Cuneus, MOG & precuneus	464	0.010	4.43	18/19	-18 -87 24
L	Premotor cortex (precentral gyrus, MFG & IFG)	379	0.020	4.29	6/9	-39 -12 51
L	Premotor cortex (SFG, MFG, med. FG)	329	0.032	4.24	6	-20 8 60
R	IFG pars orbitalis	310	0.038	4.13	47	21 29 -12
R+L	Extrastriate visual cortex (cuneus & precu-neus)	659	0.002	4.04	19	16 -91 24
Negative linear Correlation with Arousal-span				3.86	19	-6 -97 22
L+R	PCC	1597	<.001	5.60	31/29	-2 -61 24
				5.27	31	9 -57 21
R	Supramarginal gyrus	1089	<.001	4.54	40/39	51 -52 22
Positive linear Correlation with Valence-span						
L	Amygdala, subcallosal gyrus & lateral globus pallidus	868	<.001	5.35		-24 -7 -17
R	Cerebellum	1296	<.001	4.91		28 -78 -21

*Cluster level FDR-corrected for the whole brain
Abbreviations: FG – frontal gyrus; IFG – inferior frontal gyrus; IPL – inferior parietal lobule; ITG – inferior temporal gyrus; MFG – middle frontal gyrus; MOG – middle occipital gyrus; MTG – middle temporal gyrus; PCC – posterior cingulate cortex; STG – superior temporal gyrus; STS – superior temporal sulcus; H = hemisphere; L = left; R = right; p = p-value; T = T-value; B.A. = Brodmann area; x, y, z = MNI coordinates

2.3.2.2.4. Model 1: unspecific effects of lexical valence-span

After partialling out variance due to affective lexical means and lexical arousal-span, hemodynamic responses in left amygdala and globus pallidus and right cerebellum showed significant positive correlation with valence-span (Fig. 2.3, panel U; Table 2.5). No neural substrate correlated negatively with valence-span.

2.3.2.2.5. Model 2: unspecific effects of arousal ratings.

Right IFG including anterior insula (BA 47 & 13), left posterior MTG (BA 21, 39 & 37), and left IPL (BA 40) showed positive correlation with arousal ratings (Fig. 2.3, panel I to K in red color; Table 2.6).

Bilateral aTL (BA 21), dlPFC, dorsal ACC (BA 32), vmPFC (BA 11), TPJ (BA 39 & 40), peri-central cortex (BA 3, 4 & 6), and left PCC (BA 23 & 31) showed negative correlation with arousal ratings (Fig. 2.3, panel I to K in green color; Table 2.6).

2.3.2.2.6. Model 2: unspecific effects of valence ratings

Right aTL (BA 21), right TPJ (BA 40 & 22), right ACC (BA 32), vmPFC (BA 11), and left PCC (BA 23, 29 & 30) showed linear positive correlation with valence ratings (Fig. 2.3, panel M & N; Table 2.6).

Left IFG including anterior insula (BA 9 & 13), bilateral precuneus (BA 31 & 7), visual cortex (BA 18 & 19; Fig. 2.3, panel O & P; Table 2.6) and after SVC, bilateral amygdala (Fig. 2.3, panel L) showed quadratic positive correlation with valence ratings. No region showed negative linear or quadratic correlation with valence ratings.

Table 2.6. Unspecific Effects of Subjective Ratings in Model 1

H	Regions	Cluster size	p*	T	B.A.	*[x, y, z]*
Positive linear Correlation with Arousal Ratings						
L+R	Caudate body	654	0.002	5.48		0 6 18
				4.10		-9 -16 22
R	IFG pars orbitalis & triangularis	292	0.039	5.12	47/13	39 33 -8
L	IPL	441	0.011	4.74	40/13	-57 -45 30
L	Posterior MTG	304	0.039	4.05	21/39/37	-60 -54 0
Negative linear Correlation with Arousal Ratings						
L	PCC	4906	<.001	8.20	23/31	-8 -60 16
R	TPJ (AG & IPL)	4592	<.001	7.84	39/40/7	45 -67 31
R	PHC & Cerebellum	946	<.001	7.71	36/28	27 -33 -15
R	dlPFC (SFG & MFG)	2134	<.001	7.08	9/6/8	21 42 45
R+L	ACC & vmPFC (medial FG)	1688	<.001	6.59	11	3 41 -9
				5.31	11	-10 47 -14
L	Precuneus, AG & IPL	2339	<.001	6.22	19/39/7	-40 -78 37
L	TOJ (MOG, IOG & MTG)	725	<.001	5.91	19/39	-48 -82 4
L	dACC & dlPFC (MFG & SFG)	386	0.008	5.51	32/8	-16 20 42
R	aTL (MTG)	673	<.001	5.43	21	54 0 -23
L+R	Cerebellum	368	0.008	5.12		-6 -52 -50
				4.09		6 -49 -47
L	aTL (MTG)	376	0.008	5.07	21	-50 -15 -21
L	Cerebellum & PHC	965	<.001	4.97	28	-22 -30 -24

R	Precentral gyrus	353	0.009	4.94	4/6	36 -28 58
L	Postcentral gyrus	223	0.049	4.94	3/4	-48 -18 46
R	Premotor (SFG & MFG) & postcentral gyrus	244	0.040	4.53	6/4	15 -19 70
R	Precentral, postcentral gyrus & insula	443	0.004	4.21	43	54 -12 9
R	dlPFC (MFG)	240	0.040	3.91	46/9	44 29 24
Positive linear Correlation with Valence Ratings						
R	aTL (MTG & ITG)	1184	<.001	5.81	21	57 2 -23
R	TPJ (STG)	536	0.007	5.25	40/13/22	54 -51 19
L	PCC	1544	<.001	4.73	29/23/30	0 -46 13
R	ACC & vmPFC (medial FG)	716	0.001	4.40	32/11	3 32 -11
Positive quadratic Correlation with Valence Ratings						
L	IFG pars opercularis & precentral	396	0.026	5.65	9/13/6	-40 3 30
L+R	Precuneus & cuneus	1333	<.001	4.98	31/17	0 -70 15
L	SPL & precuneus	386	0.026	4.77	7	-28 -58 60
L	Precuneus & cuneus	483	0.017	4.28	7/18/19	-14 -75 34
L	Amygdala (SVC)	64	0.010	4.61		-27 0 -21
R	Amygdala (SVC)	31	0.023	4.22		27 -6 -14

* Cluster level FDR-corrected for the whole brain; voxel-level FWE-corrected for SVC
Abbreviations: ACC = anterior cingulate cortex; AG = angular gyrus; AI = anterior insula; aTL = anterior temporal lobe; dlPFC = dorsolateral prefrontal cortex; FG = frontal gyrus; IFG = inferior frontal gyrus; IOG = inferior occipital gyrus; IPL = inferior parietal lobule; ITG = inferior temporal gyrus; MFG = middle frontal gyrus; MOG = middle occipital gyrus; MTG = middle temporal gyrus; PCC = posterior cingulate cortex; PI = posterior insula; PHC = parahippocampal cortex; SFG = superior frontal gyrus; SPL = superior parietal lobule; STG = superior temporal gyrus; SVC = small volume correction; TOJ = temporo-occipital junction; TPJ = temporo-parietal junction; vmPFC = ventromedial prefrontal cortex; H = hemisphere; L = left; R = right; p = p-value; T = T-value; B.A. = Brodmann area; x, y, z = MNI coordinates

2.3.2.3. Discussion of unspecific effects at lexical, intra- and supra-lexical levels

2.3.2.3.1. Unspecific effects of affective mean lexical variables and inter-lexical variables.

We obtained robust correlations of the affective lexical variables with the BOLD signal intensities (Table 2.4 & 2.5). Most remarkably, in Model 1, we found a significant positive linear correlation in both amygdalae with lexical arousal means as well as with valence-span. The amygdala was proposed to be an integral part of the emotion network in general (Costafreda et al., 2008; Lindquist et al., 2012; Murphy et al., 2003; Phan et al., 2002), and the salience network in particular (Seeley et al., 2007), and our result is in line with a previous study on the comprehension of texts containing emotional information (Ferstl et al., 2005). Correlated activity in ACC, PCC, vmPFC, and PHC is associated with emotion conceptualization (Lindquist et al., 2012).

Among other neural correlates associated with lexical means and spans (Table A.1 & A.2), IFG, aTL, and TPJ are all associated with the ELN (Ferstl et al., 2008), with ToM or affective empathy processing (Altmann et al., 2012, 2014; Mar, 2011; Walter, 2012), and with multi-modal semantic integration (Binder & Desai, 2011; Binder et al., 2009). In addition, aTL, vmPFC, and PCC have been associated with emotional semantic processing (Binder & Desai, 2011; Bohrn, Altmann, Lubrich, et al., 2012).

The fact that affective lexical values correlated with activity in many emotion-related brain areas provides strong evidence for the assumption that lexical surface features play an important role for the overall affective reading experience (see Bestgen, 1994; Jacobs, 2014; Whissell, 2003b). The comparison of these effects with those of subjective passage ratings may further inform us about how adequate the estimation of a text's emotion potential from lexical affective surface features is at the neuronal level.

2.3.2.3.2. Unspecific effects of subjective passage ratings

Among first order effects for subjective passage ratings, it is most noteworthy that the hemodynamic responses in bilateral amygdala correlated significantly in a quadratic fashion with passages valence ratings. We also found significant correlations among neural substrates associated with the ELN (Ferstl et al., 2008), ToM or affective empathy processing (Altmann et al., 2012, 2014; Mar, 2011; Walter, 2012), and multi-modal semantic integration (Binder & Desai, 2011; Binder et al., 2009) like IFG, dlPFC, aTL, TPJ, PCC, dorsal ACC, vmPFC as discussed in the previous section.

2.3.2.3.3. Shared variance between unspecific effects of affective lexical variables and subjective passage ratings.

All results presented so far cannot be attributed exclusively to either of the relevant text levels: they potentially represent unspecific effects of variance shared by passage ratings and affective lexical variables. Indeed, we found several neural substrates for which correlations between neural activity and emotional variables are consistent concerning both affective lexical variables and subjective passage ratings. Most importantly, amygdala activity correlated with valence ratings in a quadratic fashion, and with mean lexical arousal values and valence-span in a linear fashion. This corresponds well with the classical U-shaped distribution of valence and arousal (Bradley & Lang, 1999; Lewis et al., 2007; Võ et al., 2009). Moreover, in the two dimensional affective space described by valence and arousal (Russell, 1980, 2003), both arousal and quadratic valence are measures of emotional salience (Lewis et al., 2007). The linear correlation of activation with lexical arousal and the quadratic correlation with valence ratings support the notion that it is emotional intensity, in terms of both valence and arousal, and attention to (emotionally) salient stimuli – rather than a specific type of emotion, i.e., positive vs. negative

– that is crucial for amygdala activation (Anderson & Sobel, 2003; Costafreda et al., 2008; Small et al., 2003; Wallentin et al., 2011). Other neural substrates showing consistent correlations with BOLD responses for both affective lexical variables and subjective passage ratings include ACC (BA 32), PCC (BA 31), vmPFC (BA 11), PHC (BA 36 & 28), bilateral precuneus (BA 7), left IPL including SMG (BA 40 & 39), right middle temporal cortex (BA 21), and right dlPFC (BA 8).

Despite the problem of unambiguously attributing unspecific effects to the lexical or supralexical level in particular – due to shared variance between the two – the fact that affective lexical variables and passage ratings could account in parallel for such a big range of effects concerning activity in emotion-related brain area is additional strong evidence for the general assumption that the emotional impact of texts can be adequately predicted by merely averaging affective values for constituting words at the lexical surface level. Unlike in Bestgen (1994), our computation of lexical affective means was not even based on an exhaustive sample of values for all words, but rather on valence and arousal values for 54% of content words as provided by a recent large scale normative German lexical database featuring valence and arousal ratings for 6,600 words. However, these matches probably involve a very high percentage of emotionally relevant words comprised in the texts, because attempting to include as many emotionally relevant words as possible was a main construction principle of this database. Our data thus show for the first time that emotional brain responses to complex texts can be directly predicted by text surface features at lexical level as provided by large scale normative databases – in much the same way as using individual affective evaluations of the complete passages.

2.3.2.4. Results of differential effects specific to lexical, inter-lexical, and supra-lexical levels in fMRI analyses

2.3.2.4.1. Model 1: differential effects of arousal ratings

After partialling out the variance due to affective lexical mean and span variables, the hemodynamic response in left temporo-occipital junction (BA 19 & 39) showed a significant negative correlation with passage arousal ratings (Table 2.7).

2.3.2.4.2. Model 1: differential effects of valence ratings

We found the hemodynamic response in left posterior MTG (BA 21) to be negatively correlated with valence ratings in a quadratic fashion (Table 2.7).

2.3.2.4.3. Model 2: differential effects of mean lexical arousal

We found no neural substrate in which the hemodynamic response is specifically correlated with mean lexical arousal values.

2.3.2.4.4. Model 2: differential effects of mean lexical valence

After partialling out the variance due to subjective passage ratings, lexical arousal- and valence-span, and mean lexical arousal, hemodynamic responses in right lower TOJ, including PHC, fusiform and lingual gyrus (BA 19), right STS (BA 22), and left amygdala after SVC, correlated positively with mean lexical valence (Table 2.7, Fig. 2.4A). No neural substrate showed significant negative linear correlation or quadratic correlation with mean lexical valence.

2.3.2.4.5. Model 3: differential effects of lexical arousal-span

After partialling out the variance due to the subjective passage ratings and mean lexical valence and arousal values, the hemodynamic response of the following neural substrates correlated positively with arousal-span (Fig. 2.4, panel B to D): left IFG pars triangularis including anterior insula (Fig. 2.4C; BA 13, 45 & 46), left premotor cortex (BA 6), bilateral posterior MTG and ITG (BA 37), left MTG and fusiform gyrus (BA 20 & 37), left middle cingulate gyrus (BA 24), right occipital pole (BA 17, 19 & 30), right globus pallidus and thalamus (ventral lateral nucleus and pulvinar; Fig. 2.4D, Table 2.7) and, after SVC, the left amygdala.
The hemodynamic response of the right PCC (BA 23 & 31) and precuneus (BA 7; Table 2.7) showed a significant negative correlation with arousal-span.

2.3.2.4.6. Model 3: differential effects of lexical valence-span

After partialling out the variance due to the subjective passage ratings, lexical means, and lexical arousal-span, the hemodynamic response in right occipital base (BA 19) and two clusters in right cerebellum correlated positively with valence-span (Table 2.7). No neural substrate correlated negatively with valence-span.

Table 2.7. Differentiated Effects of Affective Lexical Variables and Subjective Passage Ratings

H	**Regions**	**Cluster size**	**p**	**T**	**B.A.**	***[x, y, z]***
Model 1: Negative linear Correlation with Arousal Ratings						
L	TOJ (MOG, MTG & IOG)	642	0.007	4.49	19/39	-45 -84 0
Model 1: Negative quadratic Correlation with Valence Ratings						
L	Posterior MTG	1723	0.000	5.71	21	-63 -48 3
Model 2: Positive linear Correlation with Lexical Valence						
R	PHC, fusiform and lingual gyrus	933	0.000	5.32	19	27 -57 -8
R	STS (STG & MTG)	519	0.010	4.36	22	46 -27 -2
L	Amygdala (SVC)	19	0.007	4.79		-28 -4 -15
Model 3: Positive linear Correlation with Arousal-span						
L	IFG pars triangularis, insula & MFG	459	0.027	6.04	13/45/46	-40 29 12
R	Occipital pole (lingual gyrus and cuneus)	2543	0.000	5.88	19/30/17	15 -69 -8
L	Posterior MTG & ITG	1923	0.000	5.65	37/19	-57 -64 -3
R	Middle globus pallidus, thalamus (ventral lateral nucleus & pulvinar)	500	0.024	5.48		16 -7 3
L	Cerebellum, MTG, fusiform gyrus	362	0.042	5.19	20/37	-38 -45 -27
R	TOJ (MTG, MOG & ITG)	443	0.027	5.10	37	51 -61 3
L	Premotor cortex (MFG, SFG, medial FG)	392	0.036	4.72	6	-26 -4 64
L+R	Cingulate gyrus	387	0.036	4.70	24	-4 -1 46
L	Amygdala (SVC)	21	0.021	4.24		-22 -1 -26
Model 3: Negative linear Correlation with Arousal-span						
R	PCC & Precuneus	780	0.001	4.79	31/23/7	0 -57 24
Model 3: Positive linear Correlation with Valence-span						
R	Lingual gyrus & Cerebellum	622	0.009	4.70	18	16 -85 -15
R	Cerebellum	562	0.009	3.91		39 -76 -35

* Cluster level false-discovery-rate-corrected p-values

Abbreviations: FG = frontal gyrus; IFG = inferior frontal gyrus; IOG = inferior occipital gyrus; ITG = inferior temporal gyrus; MFG = middle frontal gyrus; MOG = middle occipital gyrus; MTG = middle temporal gyrus; PCC = posterior cingulate cortex; PHC = parahippocampal cortex; SFG = superior frontal gyrus; STG = superior temporal gyrus; STS = superior temporal sulcus; SVC = small volume correction; TOJ = temporo-occipital junction; H = hemisphere; L = left; R = right; p = p-value; T = T-value; B.A. = Brodmann area; x, y, z = MNI coordinates

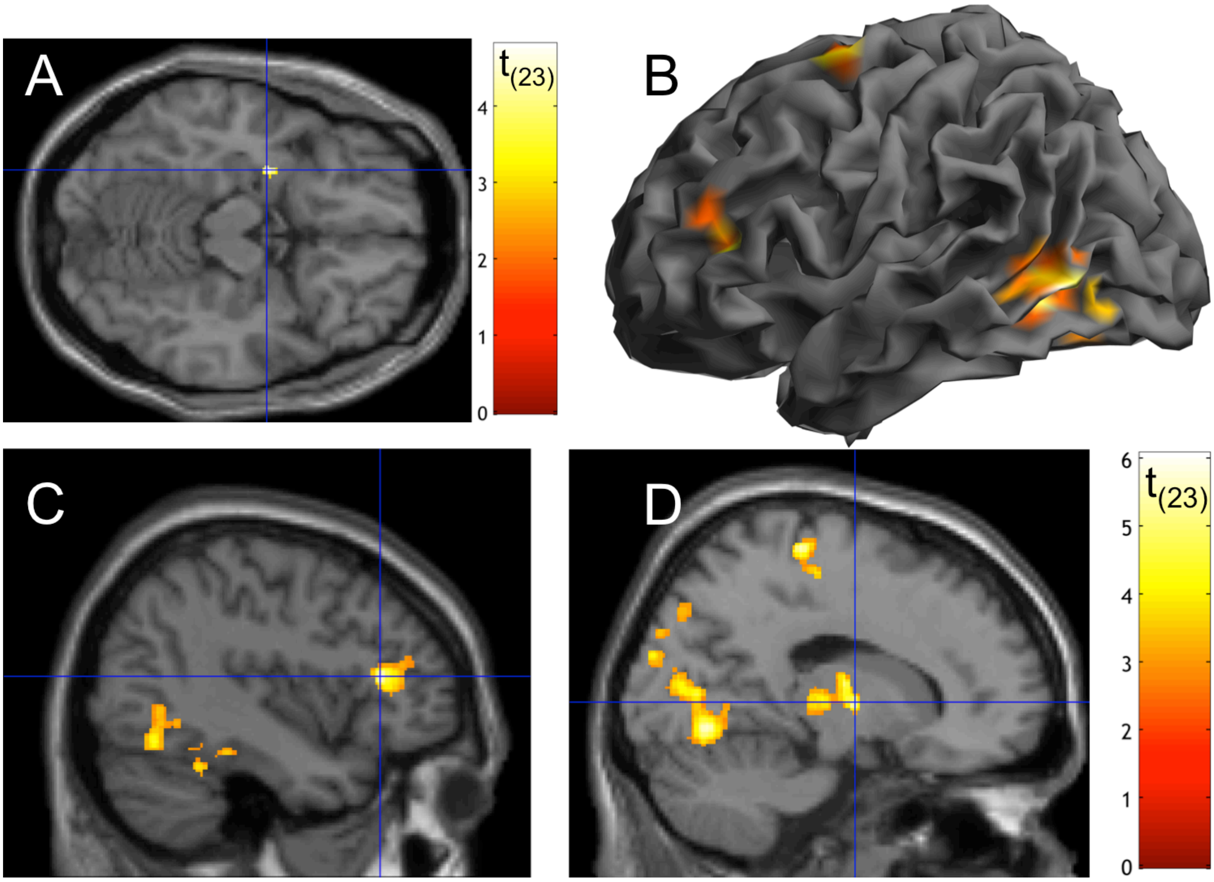

Figure 2.4. Specific Effects of Affective Lexical Variables

A: transverse section at z = -15 showing significant linear positive correlation between BOLD responses in the left amygdala (crosshair, -28 -4 -15, after SVC) and lexical valence means after partialling out variance due to ratings, spans, and lexical arousal means in Model 2.

B to D: results of significant positive correlation between BOLD responses and arousal-span after partialling out variance due to ratings, lexical means in Model 3.

B: left hemisphere render showing significant clusters in left IFG including insula, premotor area, and temporo-occipital junction.

C: sagittal section at x = -40 highlighting the significant cluster in left IFG and insula (crosshair, -40 29 12).

D: sagittal section at x = 16 highlighting the significant cluster in right globus pallidus and thalamus (crosshair, 16 -7 3).

The initial voxel-level threshold is uncorrected $p < 0.005$, the size threshold is according to the cluster-level FDR correction in each analysis.

2.3.2.5. Discussion of differential effects of affective lexical variables on neural activity

2.3.2.5.1. Differential effects of mean lexical valence values

Our second parametric model revealed neural correlates representing effects of the emotion potential of words that go beyond 1) the holistic reading experience (as consciously expressed in passage ratings) and 2) effects due to inter-lexical affective variables (i.e., span). Our present finding of increasing lexical valence triggering amygdala activation after partialling out rating and arousal effects seems well in line with a recent EEG study that showed that early attention shifts to emotional words are restricted to the positive valence domain, once arousal is held constant (Recio et al., 2014).

2.3.2.5.2. Differential effects of lexical arousal-span

We found significant correlations between lexical arousal-span and hemodynamic responses in many neural substrates, representing the emotion potential of dynamics and contrasts of arousal across the words constituting the text – beyond passage ratings and mean lexical values, effects of which had been partialled out. The neural correlates included striate and extrastriate visual cortex, amygdala, left anterior insula (extending from IFG), and thalamus. The latter three belong to the core affect regions in the psychological constructionist hypothesis of emotion (Lindquist et al., 2012), and the salience network (Seeley et al., 2007).

The anterior insula (BA 13), in which the activity is correlated with arousal-span, has been associated with awareness of bodily sensations and affective feelings (Craig, 2002, 2003, 2009), and the integration of autonomic and visceral information with emotional and motivational functions (Jones, Ward, & Critchley, 2010). Insula activation has also been shown to reflect interactive effects of emotional valence and arousal on lexical processing of emotional words (Citron et al., 2014), and to be responsive to discrete emotion information in words, in particular disgust (Ponz et al., 2013).

The activity in the striate and extrastriate visual cortices correlated with arousal-span probably represents enhanced visual processing via an attention gain control mechanism exerted by the amygdala through the direct connection with the visual cortex (Herbert et al., 2009), and the indirect modulation through a fronto-parietal network as proposed in the Multiple Attention Gain Control (MAGiC) Model (Pourtois et al., 2013). Furthermore, arousal-span correlated positively with activation in bilateral premotor cortex (BA 6) and right middle globus pallidus. Respective activity in neural substrates associated with motor function, especially the premotor cortex, could reflect elicitation of action tendencies or preparation for action – implicitly associated with arousal in the component process model of emotion (Scherer, 2005). Motion-associated neural substrates have also been shown to be associated with embodied processing of abstract emotional meaning (Moseley et al., 2012). Lesions in globus pallidus have been associated with poor motivation, poor reward sensitivity, and apathy (Adam et al., 2013; Rochat et al., 2013; Vijayaraghavan, Vaidya, Humphreys, Beglinger, & Paradiso, 2008), while functional connectivity between right nucleus accumbens and right globus pallidus seems to be weaker in apathetic depressed patients than healthy controls (Alexopoulos et al., 2013). The meta-analysis of Hattingh et al. (2012) showed that patients with social anxiety disorder have stronger activation in right globus pallidus when perceiving socially emotive cues than healthy controls. Thus, apart from the association with motoric embodied emotion processing, activity in right globus pallidus may possibly be associated with the processing of reward or fear/anxiety – correlated with the increase of arousal-span in our data. The robust correlation between lexical arousal-span of texts and emotion-related neural correlates supports the idea that this variable is a promising predictor of emotional experience related to suspense and immersion in reading (Jacobs, 2011, 2014).

2.3.2.5.3. Differential effects of subjective passage ratings

After partialling out variance accounted for by affective lexical variables, we found no emotion-associated neural activation to be correlated in particular with valence or arousal ratings. Instead, we found negative correlation with arousal ratings and the quadratic term of valence ratings in left posterior temporal cortex and higher-level visual cortex. This indicates that increasing perceived emotionality at the supra-lexical level might override cognitive ToM processing (Walter, 2012), the default network (Buckner, Andrews-Hanna, & Schacter, 2008) activity, or the attention level/focus during narrative reading. “Null effects” concerning residual variance for ratings also suggest that when reading our stimulus material (i.e., selected Harry Potter passages with rather unambiguous and passage-wise consistent specific emotional contents), the emotional salience and connotations of the constituting words and the dynamics/contrasts among them can – alone – account for the overall pattern of activity in emotion-related neural networks.

2.4. General discussion, limitation and conclusion

In this study, we investigated to what extent the affective impact of larger text units on the reader is a function of the emotional values of the words constituting them.

We therefore considered the intercorrelations between three sources of data: 1) affective lexical variables provided by existing affective word databases (Conrad et al., in prep., see also BAWL-R and ANGST), representing lexical surface features; 2) subjective passage ratings of valence and arousal, representing the 'holistic' evaluation of the emotional reading experience by the readers; and 3) BOLD responses representing neural activity during reading

Intuitively, emotions we experience are generally considered a most individual, intimate and private issue – especially when, for instance, reading a book. Therefore, one can assume that participants' individual affective evaluations should be the best predictors of their brain activity in emotion-related areas when reading a text. Besides robust parametric (unspecific) effects for such ratings given in our data, the results show that brain activity can be predicted with at least comparable efficiency via normative affective values of lexical surface features, as provided by large scale databases providing affective ratings of words – that is via quasi objective, quantifiable patterns of basic elements, completely visible to everybody at the surface of a text. Our study, thus, builds upon previous behavioral approaches (Bestgen, 1994; Whissell, 2003b) in trying to predict the emotional impact of text via the mean affective values of constituting words; the considerable overlap between parametric effects of individual passage ratings on the one hand and those for lexical valence and arousal means on the other – concerning their correlations with brain activity – in principle corroborates this view. In addition, our data also go a step further in providing evidence for genuine lexical effects beyond those of whole text ratings: mean lexical valence of words in a text still correlated significantly with amygdala activation after all alternative predictors' effects had been partialled out. We propose that these effects might reflect the special power of words to evoke affect in the following ways: Emotion-laden words have the potential to capture attention (Kissler et al., 2006) – and they do so in at least a partially context-independent manner (Delaney-Busch & Kuperberg, 2013; Wang et al., 2013); in addition, when we read a text, specific words reverberate in our minds beyond the more complex message conveyed by the text; and finally, the art of choosing the *right* words with the appropriate affective impact is part of what defines the skill of good writers or speakers. Moreover, while a text is clearly more than (or different from) the sum or average of its constituting words, single words also have a meaning beyond the specific context we find them embedded in: we have encountered these words in many other contexts before and our semantic representation of these words potentially contains traces of all these different contexts – giving words potentially complex emotional connotations. Superficially, these may not have much to do with the specific text we read, but rather the automatic activation of complex emotional connotations in our memory may add the lexical grain of affective salt that flavors text processing, therefore enabling us to joyfully read between the lines.

Furthermore, our data revealed the obvious limitations of the "lexical mean approach" by providing evidence for the importance of dynamic shifts concerning emotional content of words across a text for affective reading experience: These shifts and their relevance cannot be captured via lexical means, because increasing shifts would always make means drift towards the neutral mean of the respective scale.

Accordingly, after partialling out the influence of alternative predictors including lexical means, the span of lexical arousal values of words encountered in a text passage proved to be the most fruitful differential predictor of activation in emotion-related brain area in our study. Respective findings involved the salience and emotion processing network and it seems plausible that sharp affective contrasts that we encounter between different elements of a text are particularly salient and trigger a range of emotional responses – in particular those involving preparation of immediate reactions of the organism to unexpected emotionally relevant events (Lang, Bradley, & Cuthbert, 1998; Scherer, 2005). In sum, our data show that

1) affective evaluation of texts is strongly associated with mean and spread of lexical affective values,
2) means of lexical affective values and mean affective text evaluations both predict a widely shared pattern of brain activation in emotion-related brain area.
3) arousal-span represents a fruitful operationalization for the prediction of the emotion potential of texts at the inter-lexical level.

The absence of differential effects specific to the individual affective ratings of passages remains a particular finding that cannot necessarily be generalized. We would certainly not claim that the emotional impact of all literary productions could always be predicted in similar, sufficient ways via lexical and inter-lexical surface features as in our study. Rather, some aspects of our approach (concerning stimulus length and selection, questions of literary genre and stylistics) may have particularly favored effects specific to lexical features to arise; other types of stimuli such as entire poems (Lüdtke et al., 2014) may instead be more appropriate to show that the whole is more than the sum of its parts when it comes to neural emotional correlates of literary reading.

For instance, one may argue that short text samples of only four lines (like our stimuli) may simply not provide enough context to evoke specific supra-lexical effects. On one hand, the respective probability of detecting unique supra-lexical effects may indeed increase with text length. But notice that in the present case of a parametric approach, a rather large number of stimuli involving a sufficient spread of manipulated variables are necessary – which constrains possible individual stimulus length for reasons of maximum experiment duration. On the other hand, however, many different factors may account for supra-lexical emotional effects, e.g., figurativeness, context, event/situational change, affective empathy, or suspense, and not all of them necessarily require particularly long texts. In fact, metaphors, idioms, and irony/sarcasm can evoke emotional effects already at the *sentential* level (Bohrn, Altmann, & Jacobs, 2012; Citron & Goldberg, 2014).

Additional evidence comes from Gernsbacher et al. (Gernsbacher, Goldsmith, & Robertson, 1992; Gernsbacher, Hallada, & Robertson, 1998; Gernsbacher & Robertson, 1992), who used short stories of 5 to 6 lines that led participants to correctly identify the emotional status of the protagonist, without explicitly using emotion-laden words. Furthermore, the current study follows the design of Altmann et al. (2012), who presented stories of five lines, line by line, in the scanner. The authors showed the effective connectivity from the medial prefrontal cortex to other regions involving affective empathy and ToM processing, including left amygdala and bilateral insula, when reading negatively vs. neutrally-valenced short stories. Specifically, the medial prefrontal cortex is associated with moral judgement when negative stories are liked by the reader. All these results clearly seem to reflect supra-lexical effects. In the current study, all our participants were sufficiently familiar with the novel-specific contents, hence contextual knowledge, which is necessary for supra-lexical emotional effects to arise, was present even if participants read only short passages.

However, stylistic elements usually relax or untie the relation between affective features of lexical elements and the possible affective impact of a text. Therefore, a possible explanation of why our study failed to obtain specific supra-lexical effects beyond may lie in the specific choice of literature. Harry Potter books are aimed to be read by a broad population of readers, and its content might be relatively straightforward to comprehend in comparison with other literary materials, e.g., works by Proust, Chekhov, or Tolstoy. For example, in other literary works, authors may deliberately provide ambiguous information for the closure of *meaning gestalts* (Iser, 1976), so that readers would constantly consider new interpretations and possible outcomes upon reflection (Jacobs, 2011).

In contrast, in our selected passages emotional content was rather straightforward, lacking more sophisticated stylistic elements that may have specifically contributed to the supra-lexical emotional reading experience (Jacobs, 2014). Finally, methodological constraints of fMRI, in particular the low temporal resolution of the BOLD response, let us choose text passages in which the emotional content evolved over the entire text passage in rather consistent ways. Clearly, such (consistent) stimulus characteristics are at odds with specific literary phenomena of sharply disrupting previously cheerfully nourished expectations that presumably evoke strong supralexical emotional effects as, for example, in the poems of Heinrich Heine (see deVega, Diaz, & Leon, 1997; deVega, Leon, & Diaz, 1996; Speer, Reynolds, Swallow, & Zacks, 2009; Speer et al., 2007 for psychological accounts of pertinent (rapid) updates of situation models).

To conclude, our data make a strong case for the prevailing importance of basic features concerning the emotional impact of overall very complex samples of human communication: the mean and spread of affective features of single words encountered in texts. Future studies will hopefully extend and differentiate these findings to different literary genres and styles tapping into more specific peculiarities of literary reading at the supra-lexical level.

3. Fiction Feeling, Affective Empathy, and Immersive Reading Experience[4]

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4. How Descriptions of Supra-natural Events Entertain and Enchant[5]

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Abstract

Literature containing supra-natural, or magical events has enchanted generations of readers. When reading narratives describing supra-natural events, readers mentally simulate a text world different from the real one. The corresponding violation of world-knowledge during this simulation likely increases cognitive processing demands for ongoing discourse integration, catches the attention of readers, and might thus bring about the pleasure and deep emotional experience associated with specific reading experience. In the present study, we presented participants in an MR scanner with passages selected from the Harry Potter book series, half of which described magical events, while the other half served as control condition. Passages in both conditions were closely matched for relevant psycholinguistic variables including, e.g., emotional valence and arousal, passage-wise mean word imageability and frequency, and syntactic complexity. Post-hoc ratings showed that readers considered supra-natural contents more surprising and more strongly associated with reading pleasure than control passages. In fMRI data, we found stronger neural activation in the supra-natural than in the control condition in bilateral inferior frontal gyri, bilateral inferior parietal lobules, left fusiform gyrus, and left amygdala. The increased activation in the amygdala (part of the salience and emotion processing network) appears to be associated to feelings of surprise and the reading pleasure, which supra-natural events, full of novelty and unexpectedness, brought about. The involvement of bilateral inferior frontal gyri likely reflects higher cognitive processing demand due to world knowledge violations, whereas increased attention to supra-natural events is reflected in inferior frontal gyri and inferior parietal lobules that are part of the fronto-parietal attention network.

[5] This chapter was under review by *PLOS One* as "The magical activation of left amygdala when reading Harry Potter: An fMRI study on how descriptions of supra-natural events entertain and enchant." at the time of dissertation submission.

4.1. Introduction

Literary reading brings pleasures that are unique and important to human beings (Kringelbach et al., 2008; Nell, 1988; Schrott & Jacobs, 2011). Interestingly, part of these pleasures seems to get more intense with increasing distance between what we read about and everything we ever have or ever will experience in our real lives. Supra-natural, or magical events in fictional literature like fairy tales enchant readers from an early age on, though even the very young audience seems to be aware of the "trick": With a property attribution task, Sharon and Woolley (2004) found that 4- and 5-year-olds' abilities to differentiate between properties of real (child, clown) versus fantastic (Santa, Fairy, Superman) entities were the same as in adults (Subbotsky, 2012). Involvement in magical thinking has been shown to facilitate creativity in children (Subbotsky, Hysted, & Jones, 2010). The present study aimed to investigate the neural correlates of reading about magical events in fictional literary texts in adult readers. The representation of magical events can be considered quite a demanding or sophisticated case of meaning construction, because for the sake of discourse processing, the reader is required to accept something she or he knows to be impossible in the real world. On the other hand, fantasy literature, typically involving descriptions of such impossible events, represents a most successful literature genre. Here, we wanted to explore how the brain processes the emergence of magic in the virtual world a book creates in our mind.

From a theoretical perspective, discourse comprehension involves three different processing steps (Schmalhofer & Glavanov, 1986; Van Dijk & Kintsch, 1983): 1) the construction of the *surface structure* of a text, which is a mental representation of the exact text read; 2) a *text-base representation*, which contains idea units explicitly stated in the text, including bridging inferences that help connecting consecutive clauses; and 3) a *situation model* of the text, in which the current linguistic input (i.e., the linguistic meaning of the sentence or paragraph being read) is integrated with both general world knowledge and the prior discourse context (Graesser et al., 1997; Zwaan & Radvansky, 1998). Supra-natural events, or magical events in discourse involve world-knowledge anomalies, the processing of which should engage the left inferior frontal gyrus (LIFG): Hagoort's (2005) proposal that world knowledge integration takes place in LIFG is indeed supported by studies suggesting that world knowledge anomalies caused stronger activation in LIFG (Hagoort et al., 2004), or bilateral IFG (Menenti et al., 2008), as does meaning making with novel metaphors (Forgacs et al., 2012) and processing of figurative language in general (Bohrn, Altmann, & Jacobs, 2012).

Besides such specific responses to evident world-knowledge violations, readers seem to generally adopt different reading strategies for fictional as compared to factual texts: Unlike reading texts that merely describe certain events or facts, reading fiction involves processes of constructive content imagination and simulation (Mar & Oatley, 2008), especially perspective taking and relational inferences (Raposo, Vicens, Clithero, Dobbins, & Huettel, 2011) that bring enjoyment specific to fictional reading. Altmann et al. (2012, 2014) could show that respective differences in brain activation already emerge at a paratextual level depending only on whether readers believe a text to be factual or fictional: They presented short stories containing negatively valenced plots (crimes, disasters, accidents) and short neutral stories to participants after telling them that they were either reading invented stories (fictional) or real (factual) stories. Results showed that reading attitude or strategy for fictional texts was correlated with brain activity in right lateral frontopolar cortex associated with constructive content simulation (Addis, Pan, Vu, Laiser, & Schacter, 2009), as well as in posterior cingulate cortex (PCC) and left precuneus related to Theory of Mind (ToM) and affective empathy (Frith & Frith, 2003; Mar & Oatley, 2008). The effective connectivity between right lateral FPC and ToM related medial prefrontal cortex (mPFC), PCC, precuneus, and anterior temporal lobe (aTL) suggests that perspective taking and relational inferences (Raposo et al., 2011) are required for the simulation processes when reading about events we consider as fictional.

In this study, we presented participants with entire text passages from a popular book series that has magically enchanted numerous readers across the globe – Harry Potter – to explore the neural correlates of processing supra-natural events in the context of fantasy literature – an extremely popular literature genre, whose enormous success asks for scientific explanations, including the neuronal level.

Harry Potter combines in an exemplary way the different textual aspects mentioned above that might constitute the specific fascinating experience inherent to fantasy literature: the unmistakable awareness of the fictional text character (due to the perfectly known character of Harry Potter) is likely to put readers in a predisposition for increased mental simulation (Altmann et al., 2012, 2014). Furthermore, descriptions of magical events violates world-knowledge, catches the attention of readers (Pourtois et al., 2013), and bring about the novelty and emotional richness associated with the affective and aesthetic pleasure often characteristic of literary reading (Jacobs, 2011, 2014; Miall & Kuiken, 1994; Oatley, 1995).

Based on previous results (Hagoort et al., 2004; Menenti et al., 2008) and a recent neurocognitive model of literary reading (Jacobs, 2011, 2014; Jacobs, Lüdtke, & Meyer-Sickendiek, 2013), we propose that the violation of world knowledge contained in described supra-natural events should increase the cognitive demand of world knowledge integration, and that the related novelty, unexpectedness, and uncertainty should activate the salience/emotion network (Lindquist et al., 2012; Seeley et al., 2007), which should further recruit the fronto-parietal attention networks (Corbetta et al., 2008; Corbetta & Shulman, 2002; Pourtois et al., 2013). Due to the limited temporal resolution of fMRI, we do not intend to disentangle different processes taking place in a sequence. We rather expect to reveal conjoint neural correlates of three processes related to the mental simulation of supra-natural events in the following neural substrates: 1) the knowledge-integration network, with the IFG as the core region (Hagoort, 2005; Hagoort et al., 2004; Menenti et al., 2008); 2) the salience network (Seeley et al., 2007), mainly including OFC, dorsal anterior cingulate, anterior insula, amygdala, and other subcortical structures which are also highly associated with emotion processing (Lindquist et al., 2012), particularly the amygdala (Costafreda et al., 2008); and 3) the fronto-parietal attention network, including temporo-parietal junction (TPJ), inferior parietal lobule (IPL), ventral frontal cortex including middle frontal gyrus, IFG, frontal operculum, and anterior insula (Corbetta et al., 2008; Corbetta & Shulman, 2002; Viviani, 2013).

4.2. Materials and Methods

4.2.1 Stimuli

We selected twenty passages describing supra-natural events for the Supra-natural condition and twenty passages devoid of supra-natural events for the Control condition from all seven Harry Potter (HP) novels (Rowling, 1997, 1998, 1999, 2000, 2003, 2005, 2007) and the authorized German translations (by Klaus Fritz, Carlsen Verlag, Hamburg). To avoid habituation to magic situations, stimuli were embedded in a total of 120 text passages that overall provided a wide range of emotional content typical for this type of literature. Beyond the topic of the present study, the entire stimulus material also served to address a research question related to bilingual language processing in highly proficient German-English bilinguals (see Chapter 5 for details). Therefore, materials were presented in either the German or the English version balancing presented language across experimental conditions. We ensured that understanding the passages did not require a high level of familiarity with HP novels.

Between the Supra-natural and Control conditions we matched the following potentially confounding factors: 1) Emotional content, operationalized in valence [$F_{(1,38)}$ = 0.008] and arousal [$F_{(1,38)}$ = 0.27] ratings collected in a pilot study from 15 German native speakers for the authorized German translations; 2) Narrative complexity, operationalized as the number of persons or characters (as a discrete variable, Pearson chi-square = 3.74; as a continuous variable, $F_{(1,38)}$ = 0.08), and the type of inter-character interaction (as a discrete variable, Pearson chi-square = 0); 3) Passage length, operationalized in numbers of letters [$F_{(1,38)}$ = 1.36], words [$F_{(1,38)}$ = 1.66], sentences [$F_{(1,38)}$ = 0.08], and subordinate sentences [$F_{(1,38)}$ = 0.19] per passage across conditions; 4) Imageability and frequency of presented concepts: Passage-wise average word imageability [$F_{(1,38)}$ = 0.0001] taken from the Berlin Affective Word List reloaded (BAWL-R; Võ et al., 2009) and the Affective Norms for German Sentiment Terms (ANGST; Schmidtke, Schröder, et al., 2014), and passage-wise average frequency of words given in SUBTLEX [log frequency $F_{(1,38)}$ = 1.16, p = 0.29] (Brysbaert et al., 2011), and Leipzig Wortschatz Lexicon [log frequency $F_{(1,38)}$ = 1.70, p = 0.20] (available at http://wortschatz.uni-leipzig.de/). The descriptive statistics of matched continuous variables are listed in Table 1.

One example of the supra-natural passage is given below: 'Crackers!' said Dumbledore enthusiastically, offering the end of a large silver one to Snape, who took it reluctantly and tugged. With a bang like a gunshot, the cracker flew apart to reveal a large, pointed witch's hat topped with a stuffed vulture. A powerful delicious smell of cooking pervaded the corridors (Rowling, 1999).

4.2.2 Ethical Statement

All participants have given written consent to take part in the experiment, which was approved of by the ethics committee of Freie Universität Berlin, and conducted in compliance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). Participants were compensated properly monetarily or with course credits for their participation.

4.2.3 Participants

Twenty-three right-handed native German speakers (sixteen female) took part in the experiment. Their age ranged from 19 to 31 (mean ± *SD* = 23.78 ± 3.73). All participants all have read at least one HP book, and had no problem understanding the novel-specific contents in German or English. All of them had normal or corrected-to-normal vision, and reported no neurological or psychiatric disorder.

Table 4.1. Balanced Emotional and Psycholinguistic Variables across Conditions

		Mean Values in Conditions	
	$F_{(1,38)}$	**Supra-natural**	**Control**
N. of Letters	1.36	250.65 ± 37.76	235.75 ± 42.93
N. of Words	1.66	41.55 ± 7.32	38.63 ± 7.06
N. of Sentences	0.08	2.55 ± 0.97	2.45 ± 1.27
N. of Subordinates	0.19	5.95 ± 1.60	6.20 ± 1.96
N. of Persons	0.08	2.40 ± 0.94	2.30 ± 1.22
Valence Rating	0.008	-0.32 ± 1.78	-0.38 ± 2.10
Arousal Rating	0.27	3.30 ± 0.85	3.45 ± 0.94
Imagineability	0.0001	4.46 ± 0.38	4.46 ± 0.46
Log-SUBTLEX	1.16	2.76 ± 0.35	2.88 ± 0.32
Log-Leipzig Freq.	1.70	0.84 ± 0.47	0.68 ± 0.26

4.2.4 Design and Procedure

A repeated measures design was applied with supra-naturality ("Supra-natural" and "Control") as the within subject factor. We divided the passages into two subsets, each containing 10 Supra-natural, 10 Control, and 40 filler text passages. During the experiment, each participant read one subset, i.e. half of the passages in each condition, in German, and the rest in English.

The experiment consisted of four runs, each containing five Supra-natural, five Control, and 20 filler passages. We pseudo-randomized the order of presentation of the 30 passages in each run. For each participant, the distribution of the presented language in conditions and runs was balanced, i.e., we ensured that runs with three German Supra-natural, two German Control, and 10 German filler passages were always followed by runs with two, three, and 10 respective German passages. Similar to the design of a successful previous text-reading fMRI experiment (Altmann et al., 2014), in the MR scanner each passage was presented for 14 s, distributed on four lines (shown 3.5 s each), and then followed by 14 s of fixation cross. The visual information was presented on a computer screen and was reflected to the participants' eyes via a mirror.

To keep participants attentive, four randomly selected passages in each run were immediately followed by an emotion-unrelated, context-specific yes/no question (e.g. 'Was Harry in a train station?' 'Was the alarm clock broken again?'), to which participants responded via button press ('yes', 'no'). Each question was presented for four seconds, which included the time for response.

4.2.5 fMRI data acquisition

Functional data were acquired on a Siemens Tim Trio 3T MR scanner. Four runs of 440 volumes were measured using a T_2^*-weighted echo-planar sequence [slice thickness: 3 mm, no gap, 37 slices, repetition time (TR): 2s, echo time (TE): 30ms, flip angle: 70°, matrix: 64 × 64, field of view (FOV): 192 mm, voxel size: 3.0 mm × 3.0 mm × 3.0 mm] and individual high-resolution T1- weighted anatomical data (MPRAGE sequence) were acquired (TR: 1.9, TE: 2.52, FOV: 256, matrix: 256 × 256, sagittal plane, slice thickness: 1 mm, 176 slices, resolution: 1.0 mm × 1.0 mm × 1.0 mm).

4.2.6 fMRI preprocessing

The fMRI data were preprocessed and analyzed using the software package SPM8 (www.fil.ion.ucl.ac.uk/spm). Preprocessing consisted of slice-timing correction, realignment for motion correction, and sequential coregistration. Structural images were segmented into grey matter, white matter, cerebrospinal fluid, bone, soft tissue, and air/background with the 'New Segment' module (Ashburner & Friston, 2005). A group anatomical template was created with DARTEL (Diffeomorphic Anatomical Registration using Exponentiated Lie algebra; Ashburner, 2007) toolbox from the segmented grey and white matter images. Transformation parameters for structural images were then applied to functional images to normalize them to the brain template of the Montreal Neurological Institute (MNI) supplied with SPM. Functional images were resampled to a resolution of 1.5 × 1.5 × 1.5 mm, and spatially smoothed with a kernel of 6 mm full-width-at-half-maximum during normalization.

4.2.7 Post-hoc ratings

To address the impact of super-natural text content at a behavioral level, we asked 20 native German speakers (12 female, age 18-54 years, mean age ± *SD* = 30 ± 10.08) who were rewarded with course credits to evaluate their subjective reading experience for our stimuli on four dimensions. Participants, again, all liked the Harry Potter novel series and had no problem understanding the passages. They were asked to rate each passage in the authorized German translation on the following dimensions scaled from 1 (not at all) to 7 (extremely): 1) *supra-naturalness*: "Does the text describe something supra-natural?"; 2) *surprise*: "Does the text passage contain surprising elements?"; 3) *reading pleasure*: "How much reading pleasure did the passage bring you?".

The questionnaire was created with SoSci Survey (Leiner, 2014) and made available to the participants on www.soscisurvey.com. We calculated mean rating values for each passage on each dimension for further analyses.

4.2.8 fMRI GLM Analyses

We calculated statistical parametric maps by multiple regressions of the data onto a model of the hemodynamic response (Friston et al., 1995). In the subject-level analysis, this model contained regressors for the passage onsets for each of the three experimental conditions (*Supra-natural*, *Control*, *fillers*). The duration for each passage was 14 seconds. The context-specific questions were modeled as the fourth condition, and each question last four seconds. The six realignment parameters were modeled as six additional regressors. Regressors were convolved with the canonical hemodynamic response function in SPM8. A temporal high-pass filter with a cutoff of 128 s was applied. Contrasts of the [*Supra-natural*] and [*Control*] conditions for each participant were used at the group level to model a random effect one-way ANOVA. A conjunction contrast of [*Supra-natural* > fixation] and [*Control* > fixation] contrasts were made in the ANOVA analysis to show the neural correlates of fictional reading in this study. Contrasts of the [*Supra-natural*] and [*Control*] conditions for each participant were used at the group level to model a random effect paired t-test analysis, to show the differential activation between two experimental conditions.

The fMRI analyses were conducted at the whole brain level. However, numerous previous studies and a connectivity study on the salience network (Seeley et al., 2007) strongly suggested that salience is a key driver for the amygdala (Bach et al., 2008; Ewbank, Fox, & Calder, 2010; Jenison, Rangel, Oya, Kawasaki, & Howard, 2011; Lindquist et al., 2012). Recent meta-analyses also strongly suggest the amygdala to be involved in emotion processing (Costafreda et al., 2008; Lindquist et al., 2012; Murphy et al., 2003; Phan et al., 2002), especially in emotional discourse comprehension (Ferstl et al., 2005). Therefore, we performed small volume correction (SVC) with a bilateral amygdala mask for contrasts comparing Supra-natural vs. Control conditions. The bilateral amygdala mask in the MNI template was defined by the WFU Pickatlas Tool (Maldjian et al., 2003).

For whole-brain fMRI analyses, we used an initial voxel-level threshold of uncorrected $p < 0.005$, then a cluster-level threshold of false-discovery rate (FDR) corrected $p < 0.05$ for the entire image volume, as suggested by Liebermann and Cunningham (2009) for studies in cognitive, social and affective neuroscience. For the SVC analyses of amygdala, we used initial voxel-level threshold of uncorrected $p < 0.005$ for the entire image volume, then the threshold of voxel-level family-wise error (FWE) corrected $p < 0.05$ after applying the SVC with a bilateral amygdala mask. The labels reported were taken from the 'TD Labels' (Lancaster et al., 1997; Lancaster et al., 2000) or 'aal' labels in the WFU Pickatlas Tool. The Brodmann areas (BA) were further checked with the Talairach Client using nearest grey matter search after coordinate transformation with the WFU Pickatlas Tool.

4.3. Results

4.3.1 Behavioral performance

All 23 participants correctly responded to context-specific questions in the scanner above chance (≥ 50%) with overall mean accuracy of 82.62% ± 14.36%.

4.3.2 Post-scan emotion ratings: valence and arousal

Post-scan ratings by 23 participants of the fMRI experiment confirmed the balance of items concerning these classical emotion dimensions across Supra-natural vs. Control conditions (valence, $F_{(1,38)} = 0.04$; arousal, $F_{(1,38)} = 0.99$).

4.3.3 Post-hoc rating effects on additional evaluation dimensions

Mean ratings for the dimensions of supra-naturalness, surprise, and reading pleasure were significantly higher in the Supra-natural than the Control condition (Table 4.2) according to Student's t-tests.

Table 4.2. Student's t-tests of Post-hoc Ratings Across Conditions

		Mean Values in Conditions	
	p-value	**Supra-natural**	**Control**
Supra-naturalness	< .0001	5.48 ± 0.93	3.19 ± 1.38
Surprise	0.0007	4.14 ± 0.76	3.18 ± 0.88
Reading Pleasure	0.0046	4.42 ± 0.36	4.09 ± 0.34

4.3.4. fMRI Results

In the conjunction of the two conditions [*Supra-natural* > fixation] and [*Control* > fixation], we found the following neural correlates that were more active in both Supra-natural and Control conditions in comparison with the baseline (Table 4.3): bilateral striate and extrastriate visual cortex (BA 17 & 18), bilateral dmPFC (BA 6), right superior and middle temporal gyrus, from anterior to posterior temporal lobe (BA 21 & 22), bilateral medial paracentral gyrus (BA 6), bilateral OFC (BA 11).

Table 4.3. Results of the Conjunction Analysis for Supra-natural and Control Conditions

H	Regions	Voxel	p	T	B.A.	[*x, y, z*]
Conjunction: [Supra-natural > fixation] & [Control > fixation]						
L+R	Occipital pole (lingual gyrus)	98670	<.001	19.53	18, 17	22 -87 -11
				18.33	17	-12 -97 -6
L+R	dmPFC (SFG, medial FG)	3282	<.001	16.37	6	-3 2 66
				7.46	6	8 12 49
R	STG, MTG	16161	<.001	13.20	22, 21	50 -28 -0
L+R	Medial paracentral & precentral gyrus	1944	<.001	7.49	6	9 -33 58
				5.39	4, 6	-8 -39 61
L+R	OFC (medial FG & orbital gyrus)	514	0.003	6.46	11	-4 47 -18
				5.30	11	3 44 -20

Abbreviations: H – hemisphere; L – left hemisphere; R – right hemisphere; T – t-values; B.A. – Brodmann area; dmPFC – dorsomedial prefrontal cortex; FG – frontal gyrus; SFG – superior frontal gyrus; MTG – middle temporal gyrus; OFC – orbitofrontal cortex; STG – superior temporal gyrus

The results of paired t-tests are listed in Table 4.4 and shown in Figure 4.1. In the contrast [*Supra-natural* > *Control*], the following neural correlates were significantly more active when participants read Supra-natural passages as compared to Control passages: two cluster in the LIFG pars triangularis (BA 46 & 13) and opercularis (BA 44 & 9), one cluster in the RIFG spanning pars triangularis and pars orbitalis (BA 45 & 47), bilateral TPJ spanning IPL and postcentral gyrus (BA 40, 3 & 2), and left fusiform gyrus (BA 37,

Fig. 4.1A-D, red color, Fig. 4.1F). After applying the SVC, activation of left amygdala was found to be significantly increased for Supra-natural passages (Fig. 4.1E).

In the contrast [*Supra-natural* < *Control*], the following neural correlates were significantly less active when participants read Supra-natural passages as compared to Control passages: the left lateral temporal cortex (BA 21 & 22) and right IPL and supramarginal gyrus (BA 40 & 39, Figure 1A-D, green color, Figure 4.1G).

Table 4.4. Results of the Paired t-test for Supra-natural vs. Control Conditions

H	Regions	Voxel	p	T	B.A.	[*x, y, z*]
Supra-natural > Control						
R	IFG pars triangularis, orbitalis & MFG	801	<.001	7.04	45, 47	50 38 6
L	Fusiform, ITG	1894	<.001	5.55	37	-48 -60 -14
L	TPJ (postcentral gyrus & IPL)	1002	<.001	5.48	2, 40	-58 -33 40
L	IFG pars triangularis	886	<.001	5.14	46, 13	-45 38 9
L	IFG pars opercularis	370	0.022	4.28	44, 9	-51 11 19
R	TPJ (IPL & postcentral)	353	0.022	4.10	40, 3, 2	66 -31 33
L	Amygdala (SVC)	139	0.016	4.45		-22 -3 -18
Supra-natural < Control						
L	MTG	443	0.021	5.01	21, 22	-64 -24 -8
R	Supramarginal, precuneus, IPL	442	0.021	4.09	40, 39	40 -55 36

Abbreviations: H – hemisphere; L – left hemisphere; R – right hemisphere; T – t-values; B.A. – Brodmann area; FG – frontal gyrus; IFG – inferior frontal gyrus; IPL – inferior parietal lobule; ITG – inferior temporal gyrus; MFG – middle frontal gyrus; MTG – middle temporal gyrus; STG – superior temporal gyrus; SVC – small volume correction; TPJ – temporo-parietal junction

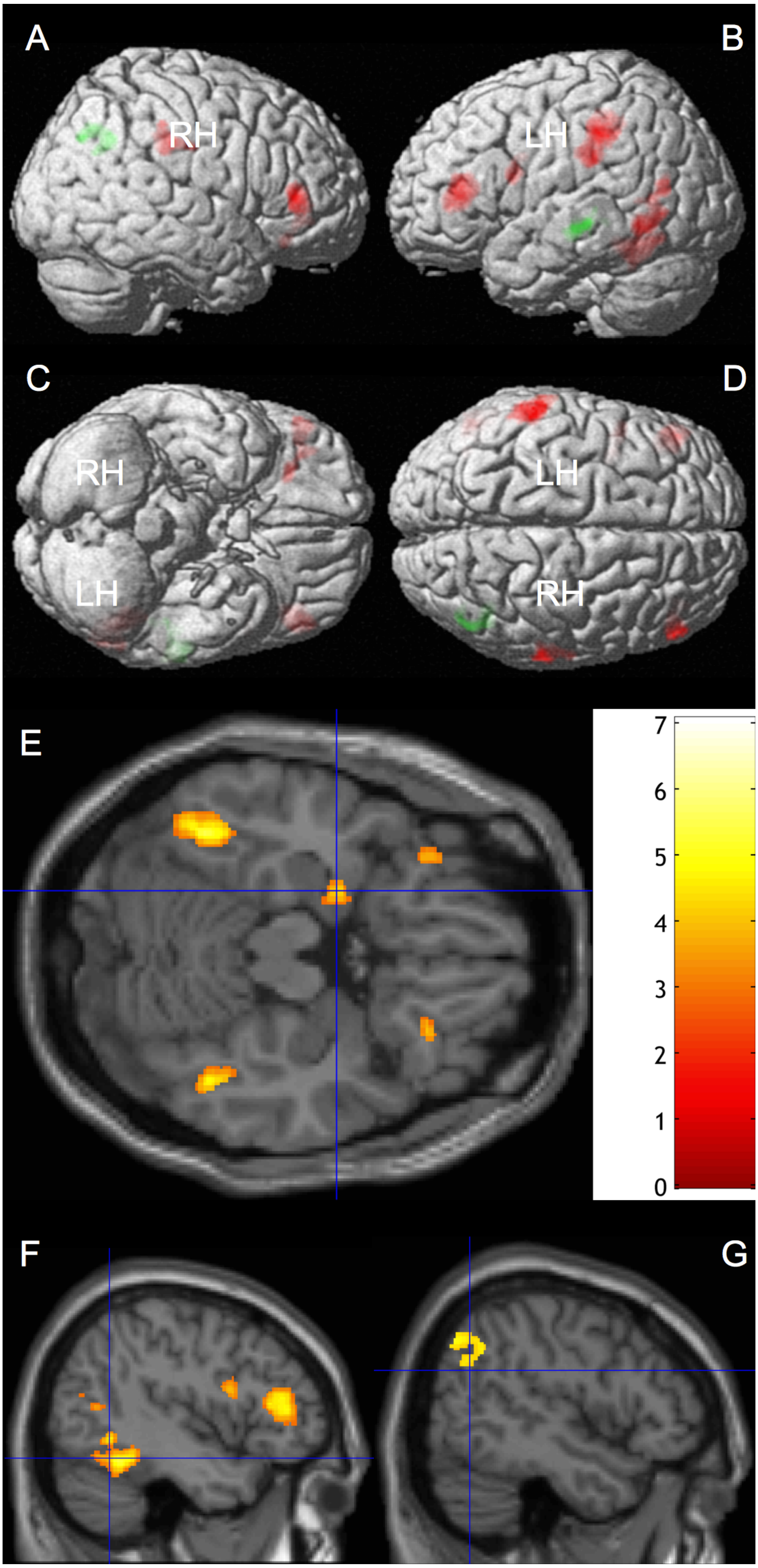
A
B
RH
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Figure 1: Effects of Supra-natural vs. Control Conditions

Regions showing significant BOLD response differences for supra-natural vs. control passages (Table 3) - created using xjView toolbox. Red color indicates significant positive differences (Supra-natural > Control). Green color indicates significant negative differences (Supra-natural < Control). A: right lateral view; B: left lateral view; C: inferior view; D: superior view;

E: transverse section highlighting left amygdala in the contrast [Supra-natural > Control]

F: sagittal section showing in the contrast [Supra-natural > Control], the cluster in the left fusiform gyrus contains the voxel (the position of the cross hair, Talairach: -43 -54 -12; MNI: -43 -55 -17) reported as Visual Word Form Area (VWFA) by Cohen, et al. (Cohen et al., 2002).

G: sagittal section showing in the contrast [Supra-natural < Control], the proximity of the significant cluster in the right supramarginal gyrus, precuneus and IPL to the voxel (the position of the cross hair, Talairach: 49 -59 27; MNI: 49 -62 26) strongly associated with autobiographical memory demonstrated in the meta-analytic study by Spreng, et al. (Spreng, Mar, & Kim, 2009).

4.4. Discussion

4.4.1 Effects of fictional literary reading

For the conjunction of the conditions [*Supra-natural*] and [*Control*] results are in line with previous results for reading (emotion-laden) texts: bilateral medial paracentral gyrus (BA 6) is associated with encoding written language (Ferstl et al., 2008; Turkeltaub, Eden, Jones, & Zeffiro, 2002). Lateral temporal cortex and dmPFC are associated with multi-modal semantic integration (Binder & Desai, 2011; Binder et al., 2009), and are part of the Extended Language Network (ELN) (Ferstl et al., 2008). The impact of general emotionality of the passages is reflected in the activity of bilateral orbitofrontal gyrus (cf. (Bohrn et al., 2013; Ferstl et al., 2005; Kuchinke et al., 2005)), and bilateral aTL, which is highly associated with emotional semantic processing (Binder & Desai, 2011).

4.4.2. Effects of supra-natural events

We proposed that reading fiction involving supra-natural events increases the cognitive demands associated with world knowledge integration, activates the salience and emotion network, and recruits the fronto-parietal attention networks.

Our results supported these hypotheses. Post-hoc ratings (Section 4.3.3) support the validity of our manipulation in terms of perceived supra-naturalness, but they also revealed important differences concerning the emotional appeal of our stimuli: despite being controlled for valence and arousal between Super-natural and Control conditions, readers found passages with supra-natural events more surprising and found reading them more enjoyable than control passages.

From neuroimaging data, we found 1) two clusters of activation in LIFG and one cluster in RIFG (exactly in BA 45 and 47) associated with increased demand of world knowledge integration (Hagoort et al., 2004; Menenti et al., 2008); 2) increased activation in the left amygdala, which is part of the salience and the emotion networks (Costafreda et al., 2008; Lindquist et al., 2012; Seeley et al., 2007); 3) activation in bilateral IFG and IPL associated with increased attention recruited by the salience of supra-natural events in the fronto-parietal attention network (Corbetta et al., 2008; Corbetta & Shulman, 2002).

In addition, we found a cluster in the left fusiform gyrus, which contained the coordinate consistently reported as Visual Word Form Area (VWFA, transformed MNI coordinate -43 -55 -17, specified in Fig. 4.1F by the crosshair, cf. Cohen et al. (2002)) being more activated in the supra-natural than in the control condition. According to the interactive perspective of visual feature processing in the fusiform gyrus (Dehaene & Cohen, 2011; Harel, Kravitz, & Baker, 2013; Price & Devlin, 2003, 2011), increased VWFA activation could be either due to top-down influence depending on task demand or to bottom-up processing of visual features like string length, bigram frequency, total line length, or the number of line endings of words and pictures (Dehaene & Cohen, 2011). As we had balanced the number of letters and words across the Supra-natural and Control conditions, increased VWFA activation is unlikely to be driven by visual feature related bottom-up processing. We consider it, instead, to be top-down attention-driven, resulting from the effort to resolve the uncertainty due to the supra-natural events by keeping up the reading process (Lindquist et al., 2012).

As it is perhaps the most important among our findings, the increased activation of left amygdala when reading about magical events deserves detailed discussion: left lateralization of the amygdala activation was also observed in other studies using linguistic material as stimuli (Herbert et al., 2009), and can be attributed to left hemispheric dominance for language processing (Markowitsch, 1998; Schirmer & Kotz, 2006) and a sign for higher emotional relevance (Sander et al., 2003) and/or affective intensity (Phan et al., 2004) of figurative language (Bohrn, Altmann, & Jacobs, 2012). The meta-analysis of Costafreda et al. (2008) has shown that the amygdala is traditionally associated with emotion processing. Many studies already suggest the amygdala to be generally sensitive to salient stimuli, including emotionally salient ones (Bach et al., 2008; Ewbank et al., 2010; Jenison et al., 2011; Lindquist et al., 2012), while Seeley et al. (2007) identified the amygdala as part of the intrinsically connected salience network.

The theoretical framework of the neurocognitive model of literary reading (Jacobs, 2011, 2014) offers an interesting account on how an interaction between salience and emotion processing could contribute to the specific experience of literary reading: Violation of world knowledge would activate the salience network, and once a text is accordingly processed as something that interestingly differs from everyday language use, the reader is set in a more receptive mood to perceive and enjoy the affective elements specific to the text (see (Bohrn, Altmann, Lubrich, et al., 2012) for fMRI data). We therefore propose the amygdala activation in the present data to be a function of salient features of magical events in a text leading to intensified affective experience – as evident at the behavioral level from increasing *surprise* and *reading pleasure* ratings for super-natural text passages. Note that our stimulus material features many highly emotional events in both conditions, but that the basic affective content of magical passages – as assessed by valence and arousal ratings – was kept comparable to those of the control condition. Thus, respective differences in amygdala activity between the two conditions should only arise as a consequence of the increased salience of supra-natural contents triggering subsequent intensified affective processing. As reflected in our behavioral data, supra-natural, or magical events seem to be clearly associated with the emotion of *surprise* (Ortony & Turner, 1990) and the hedonic experience of *reading pleasure* (Kringelbach et al., 2008; Nell, 1988; Schrott & Jacobs, 2011). Both phenomena may contribute to why common language use employs the term "magic" as a synonym of emotional intensity.

Given that the amygdala has reliably been shown to be an integral part of the spread of activation over the brain processing emotional material, the fact that this key structure of emotion processing is activated by salient supra-natural text elements may suggest that reading about events so charmingly beyond our everyday life experience lays the ground of gratifying emotional experiences associated with this literature.

Finally, we also found two clusters of neural correlates in which the activity was weaker when participants read Supra-natural passages than Control passages. The left middle temporal cortex has been associated with more basic language perception as part of the ELN (Ferstl et al., 2008), while the cluster in the right supramarginal gyrus, precuneus and IPL (peaks in MNI coordinate: 40 -55 36; 44 -72 36; 50 -69 40, Figure 1G) is right above the voxel highly associated with autobiographical memory demonstrated in a meta-analytic study (Talairach: 49 -59 27; MNI: 49 -62 26, cross hair in Figure 1G (Seghier, 2013; Spreng et al., 2009)). Thus, reading about supra-natural events, in comparison with normal passages, seems to lead to less episodic recollection of personal events from one's own life – presumably simply because such events are by definition beyond our experience.

On the other hand, the brain activation patterns observed here offer a tentative explanation of why we apparently enjoy exactly this facet of fantasy literature so much: our mental simulations of these supra-natural events occupy our attention network and thus entertain us more strongly than comparable fictional, but non-super-natural literature. Moreover, they particularly activate one brain structure that is not only involved in detecting salient events (which magical events definitely are), but most intimately linked to emotional and hedonic experience (most people presumably are striving for when reading novels): the amygdala.

4.4.3 Limitations and conclusion

In this study we investigated the neural correlates of reading about supra-natural, magical events. Our results show that supra-natural events: 1) increase the activity in bilateral IFG associated with the integration of ongoing discourse and world knowledge information; 2) activate left amygdala, which is part of the salience network involving emotion processing and further recruit the fronto-parietal attention network and VWFA, suggesting that their novelty and unexpectedness, are a source of enchantment, potentially boosting affective reading experience (Bohrn, Altmann, Lubrich, et al., 2012; Jacobs, 2011, 2014).

Given the limited temporal resolution of fMRI and the complexity of our stimulus material tapping into the complex, holistic process of reading entire text passages, we cannot exactly say whether activation in high-level associative cortices in our data is selectively more related to one or another of the above-mentioned mental processes. The activation pattern in our results is best considered as evidence for a repeated mutual interaction of (emotional) salience, attention, and world knowledge integration between amygdala and the fronto-parietal network across the whole reading process. Future research might help to further specify the relationship between the amygdala (as a salience detector) and the fronto-parietal network (as an uncertainty resolver) when reading fictional texts.

5. Can Harry Potter Still Put a Spell on us in a Second Language?[6]

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6. General Discussion and Outlook

This dissertation project is based on one fMRI experiment of reading emotion-laden and neutral literary materials. The author investigated the affectivity associated with the lexical, inter-lexical, and supra-lexical factors. On the supra-lexical level I further investigated the aspect of immersion and world-knowledge violation. Finally I looked at the general effect of the second language acquisition.

According to the dual-route neurocognitive poetics model of literary reading (Jacobs, 2011, 2014), emotional effects of the lexical and inter-lexical levels, and that of immersion due to affective empathy belong to the implicit and fast background processing. The violation of world knowledge creates a salient circumstance of foregrounding when the background semantic integration could not be performed automatically, and catches the attention of the reader. Studies in the dissertation supported the notion that the implicit and explicit processes take place in parallel. Although one route can be more dominant than the other (depending on the content), both routes contribute significantly to the emotional literary reading experience. Furthermore, the dissertation showed that the salience (Seeley et al., 2007), ELN (Ferstl et al., 2008), and ToM (Mar, 2011) networks are extensively involved in both the backgrounding, as well as foregrounding aspects of emotion processing in literary reading. The study of bilingualism also showed that the emotionality experienced is quantitatively weaker on both behavioral and neuronal levels in late bilinguals.

6.1 The neural correlates of affective processing in literary reading

Regions in which the brain activity is modulated by variables investigated in the dissertation are summarized in Fig. 6.1. While each of the regions has been discussed in the previous chapters, this section will provide further discussion on the holistic observations.

The affective variables manipulated in the current experiment modulated both the emotion-associated and the reading-associated brain regions extensively. On the neuronal level, the neural correlates are in line with several theoretical perspectives of emotion processing in reading (Section 1.8). The neural re-use theory (Anderson, 2010; Ponz et al., 2013) is strongly supported by the fact that elements of the salience network (Seeley et al., 2007), particularly the left amygdala, are extensively modulated by the different levels of emotion potential of literary texts (i.e., the general effects of quadratic valence and arousal, the specific effects of lexical valence and arousal-span, the violation of world knowledge, and the bilingualism). The amygdala is not part of the language processing network, and shown to be involved in affective processing or aversive conditioning in animals (LeDoux, 1996, 2012, 2014; Panksepp, 1998), and emotion processing of modalities other than language in human beings (Costafreda et al., 2008; Lindquist et al., 2012; Murphy et al., 2003; Phan et al., 2002).

The classical psycholinguistic hypothesis (Ponz et al., 2013) is supported by the correlated activity in the ELN (Ferstl et al., 2008) and multi-modal semantic integration regions (Binder & Desai, 2011; Binder et al., 2009). Furthermore, the theory of perspective simulation and identification (Oatley, 1995, 1999) is supported in the dissertation by the evidence for the *fiction feeling hypothesis* (Chapter 3) and the general correlational activation differences in the ToM or *affective empathy* network (Mar, 2011; Walter, 2012). Finally, the perspective of embodiment or grounded emotion (Moseley et al., 2012; Niedenthal, 2007) coincides with the correlational activity found in the peri-central cortex, the premotor cortex, caudate nucleus, and globus pallidus.

In line with the hypothesis in Section 1.8, the results suggest that the emotional experience in literary reading is a synergy of multiple parallel processes, including core affect, embodied emotion, language semantic processing, and perspective simulation. The way these factors synergize could on one hand well depend on how the artistry of the writer fine-tunes the chosen words (lexical and inter-lexical factors) and stylish elements, and builds up one's fictive world in the narrative (supra-lexical factors). On the other hand, it also depends on how the reader receives, reconstructs, and interprets the sense, feeling, tone, and the intention of the writer (e.g., how close or distant the reader to the language is, as well as other personality, genetic, and environmental factors).

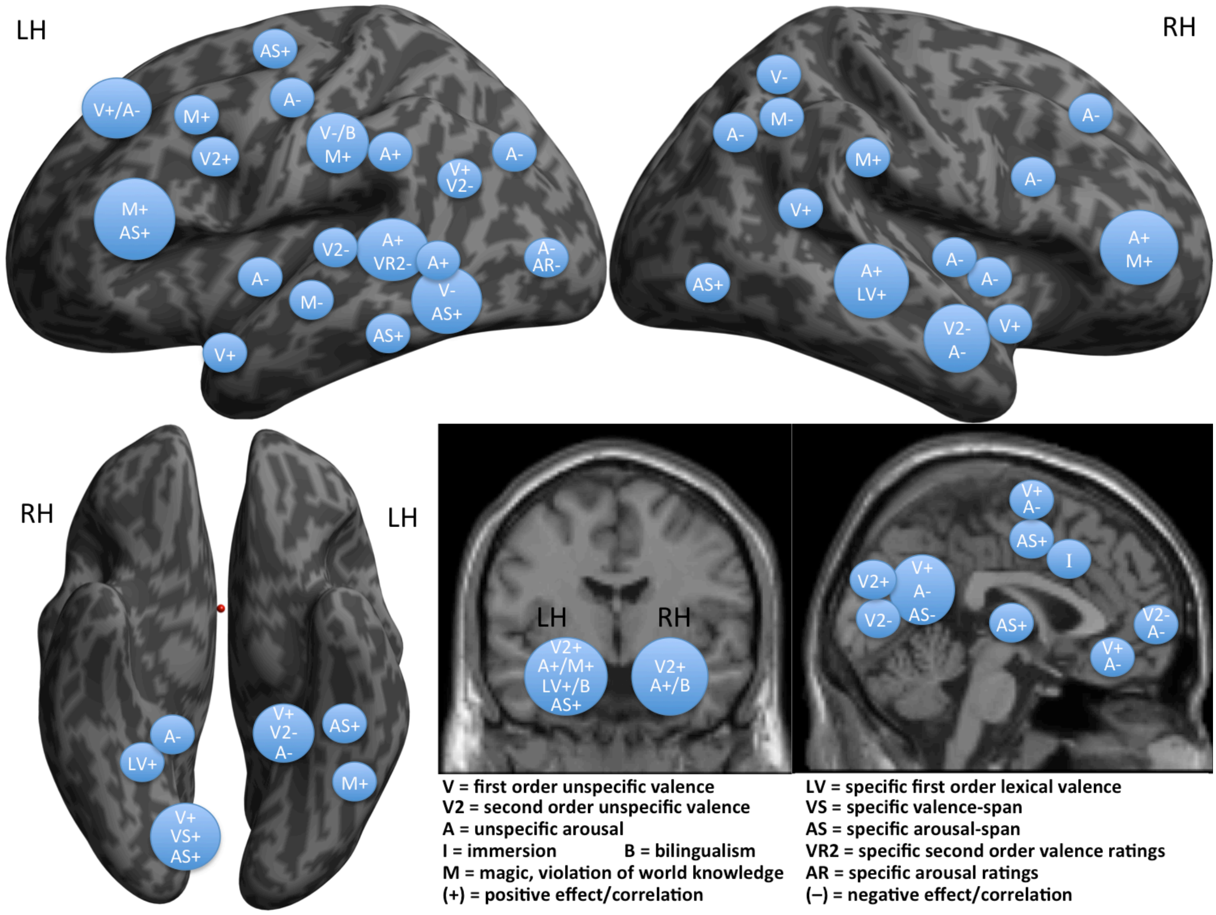

Figure 6.1. Summary of the neural correlates in literary reading.

Left upper panel: the left lateral view; right upper panel: the right lateral view; left lower panel: the bottom view; middle lower panel: the coronal section at the level of amygdala (y = -4); right lower panel: the sagittal view at the midline (x = 0).

Abbreviations: V = correlates of first order valence effects unspecific for lexical variables or ratings; LV = correlates of specific first order lexical valence effects; V2 = correlates of second order valence effects unspecific for lexical variables or ratings; VS = correlates of specific lexical valence-span effects; VR2 = correlates specific for second order valence ratings; A = correlates of arousal effects unspecific for lexical variables or ratings; AS = correlates of specific lexical arousal-span effects; AR = correlates specific for arousal ratings; I = effects of immersion; M = correlates of magic, supra-naturalness, or violation of world knowledge; B = effects of bilingualism or second language acquisition.

6.2 Limitations

As summarized in the last section, emotion-laden texts evoke brain activity in different brain networks, which can be explained by different theoretical perspectives (i.e., neural re-use, classical psycholinguistic, perspective simulation, and embodiment). Due to the correlational nature of the analyses, the use of reverse inference (Section 1.6), and the complexity of the underlying processes, with the current data, it was not possible to delineate the temporal or causal relationship between respective neural networks and how they interact with each other. However, the present results should provide a good framework for future researchers to formulate heuristic, neuroscientific hypotheses that focuses on underlying neural mechanisms and their interactions, by employing advanced methods that have the potential to overcome above mentioned limitations, such as effective connectivity, which allows causal inference, MVPA, which identifies qualitative difference in the underlying processing, and combined EEG-fMRI, or MEG for better temporal resolution.

The theoretical framework of this dissertation is based on the core affect theory by Russell (1980, 2003), which describes affect as consisting of two dimensions: valence and arousal. However, in Chapter 3, the author found the effect of world knowledge violation to be associated with higher surprise ratings and the amygdala activation, despite valence and arousal variables being balanced between experimental and control conditions. This finding suggests that some emotion perception or processing and their associated brain activity could not be completely explained by valence and arousal dimensions. While there is no consensus on a third dimension (or even further dimensions) of the affective space (Section 1.1), affective neuroscientists should consider and benefit from the perspective based on emotion categories when adopting the dimensional approach, and should consider possible interactions between these perspectives (Briesemeister et al., 2011a, 2014; Briesemeister, Kuchinke, Jacobs, & Braun, accepted pending minor revision).

Additional concerns arose due the fact that post-hoc ratings were collected for behavioral analyses (immersion in Chapter 3; supra-naturalness, surprise, and reading pleasure in Chapter 4) as well as for the calculation of passage mean rating values used as fMRI parametric modulators (Chapter 3). In these cases, there were two separate groups of participants for behavioral and fMRI data. Even though behavioral results can be generalized to the population (of native German speakers) when treating “participants” as a random factor, a more persuasive approach would be to collect ratings for the behavioral validation of the manipulation from the same participants of the fMRI experiment. Due to the length of the fMRI experiment (up to three hours including post-scan ratings), not all required dimensions could be included in post-scan ratings.

Another possible limitation concerns the fact that in Chapter 3, "immersion" is a phenomenon that includes processes of affective empathy due to effects of valence and arousal (of emotion-laden, negative, and suspenseful texts). The possible underlying factors of immersion are difficult to disentangle; therefore the author investigated it as a holistic concept in the present dissertation. However, the author has been cautious in the interpretation to avoid the consideration of immersion as a one-dimensional or homogenous affective process.

As mentioned in Chapter 2, the design of the Harry Potter experiment used short texts of 4 lines with homogeneous emotional contents. This ensured the reliability of passage ratings, but also limited the potential to detect supra-lexical emotional effects due to (rapid) situation model updating and context, which might require longer texts to arise. Since it is not possible to cover all possible aspects of emotion processing in reading in a single experiment, new paradigms will need to be developed to investigate more natural and ecologically valid emotion processing during reading of longer texts (e.g., Hasson & Honey, 2012; Lehne et al., in revision).

Finally, in comparison with other literary masterpieces, Harry Potter might appear to be relatively simple and straightforward. Pragmatically, though, it represents contemporary literary material that is relatively easy to be used for experimental manipulation and familiar to most participants to start with. Certainly, we expect that the affective processing would not necessarily be the same when reading literature from, for example Tolstoy, Proust, or Chekov. Therefore, the results of this dissertation cannot be generalized as a comprehensive account of all emotional experience of literary reading of any genre, epoch or author. More studies using different literary materials are required to further test conclusions and hypotheses based on findings in the current dissertation, which represents a pioneering effort into the investigation of the neural correlates of the literary reading experience. After the accumulation of a reasonable amount of research findings, meta-analyses of these studies will help gaining an overview of the literary reading experience, and also help teasing apart effects that can be generalized across different genres from more genre-specific effects.

6.3 Outlook

This dissertation investigated the emotion potential of the lexical, inter-lexical, and of several aspects of the supra-lexical level in literary reading. As mentioned in the introduction (Section 1.2) and included in the neurocognitive poetics model of reading (Jacobs, 2011, 2014), phonological processing also takes place at the sublexical level – in parallel with other levels. For example, literary style elements of alliteration and rhyme have long been recognized as conventional foregrounding elements. Moreover, previous studies suggest that a correlation between sound and affect, as a form of phonological iconicity (for a recent review, see Schmidtke, Conrad, & Jacobs, 2014), can contribute significantly to foregrounding effects. Whissell (1999) analyzed phonetically transcribed literary (poems and lyrics) and non-literary texts (word lists and advertisements). She found significant correlations between occurrences of phonemes classes in texts with mean valence and arousal values of words in the text (Whissell, 1999, 2000, 2001, 2003a, 2009; Whissell & Dewson, 1986). Recently, Aryani et al. (2013) developed a software tool capable to analyze sublexical phonological salience as a foregrounding element in literary texts. With this tool, Aryani, Kraxenberger, Ullrich, Jacobs, and Conrad (in preparation) showed that 10 to 22% of the variance of the affective ratings of poems by Enzensberger could be explained by their *basic affective tone*, which is based on the affective values of phonologically salient units of the poems. Related analyses of the fMRI data from the current dissertation, together with another experiment concerning the sublexical level of emotion processing, are still under progress.

This dissertation ends with the study comparing the emotionality of reading in L1 and L2 (Chapter 5). However, that study adopted a very general approach. Future research could further continue with research of bilingual emotionality in literary reading specifically at the lexical, sublexical, inter-lexical, and supra-lexical levels. Preparatory work needs to be done, e.g., a bi-/multi-lingual affective word database, covering words in the texts used as stimuli for the analyses at the lexical and inter-lexical level. When considering different aspects of the supra-lexical level, e.g., metaphor, irony, and humor, cultural differences confounded with language will need to be meticulously taken into account.

According to Hofmann and Jacobs (2014), model development is a five-step framework: 1) the modeler examines the global appropriateness of the architectural assumptions; 2) *estimator set studies* estimate model parameters; 3) *criterion set studies* test whether the model predictions can be generalized to other data with parameters fixed; 4) *strong inference studies* involve formal, criterion-guided comparisons of alternative models against the same data sets to select the best model; 5) the model has to be refined or replaced. The author considers the neurocognitive poetics model of literary reading (Fig. 1.3) to be in the first phase: its neurobiological architectural plausibility is being tested with neurocognitive data. The present dissertation supports the assumptions of the model at the affective-cognitive level concerning the background implicit processing and fiction feelings, as well as the attention capture potential of foregrounding effects. However, while foregrounding and backgrounding processes are contrasted at a conceptual level, their neural correlates – apart from the aesthetic-processing-associated reward network (Bohrn et al., 2013) – are not easily dissociable. Instead, both processes engage substrates of the salience/emotion network, as well as the partially overlapping ELN, ToM, and attention networks. Therefore, concerning the neuronal level of the model, it may be plausible to postulate that literary reading engages an extensive transcortical network comprising neural correlates of above-mentioned processes. Fore- and backgrounding elements modulate the activity of this network in both the quantitative (e.g., regional activity intensity, which was investigated and reported in the present dissertation) and the qualitative way (e.g., extensive activation pattern, modulated effective connectivity). However, as mentioned in Section 6.2, advanced methods are required to gain knowledge in this direction. On the other hand, although an affective neural network of literary reading may be extensive and involve much redundancy, it would still be informative to investigate to which extent each of the key regions of the network contributes to each of the affective sub-processes. Lesion studies and TMS would be helpful due to their potential to shed light on causal relationships.

In short, future research might further test elements of the neurocognitive poetics model in the following ways:

1) with targeted or modified neuroscientific hypotheses aiming to delineate the temporal, causal or interactive relationship between underlying mechanisms of emotion processing in reading;
2) with different choice of experimental designs, especially concerning text length, text genres, or writers to progress towards more generalizable knowledge concerning literary reading;
3) exploiting the holistic combination of parallel background vs. foreground processing as well as parallel processing in the sublexical, lexical, inter-

lexical, and supra-lexical levels when making hypotheses and designing new studies;

4) with a cross-linguistic and cross-cultural perspective.

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Appendices

A.1. List of Stimuli Used

Table A.1.1. List of Stimuli Used

German Passage	English Passage	Emotion	Magic
Klar, sagte Harry, gespannt darauf, mehr von Hagrids Zauberkünsten zu sehen. Hagrid zog den rosa Schirm hervor, schlug ihn zweimal sachte gegen die Seitenwand des Bootes, und schon rauschten sie in Richtung Küste davon.	Of course not, said Harry, eager to see more magic. Hagrid pulled out the pink umbrella again, tapped it twice on the side of the boat and they sped off towards land.	H=happy	M=magic
Harry ergriff den Zauberstab. Plötzlich spürte er Wärme in den Fingern. Er hob den Stab über der Kopf und ließ ihn durch die staubige Luft herabsausen. Ein Strom roter und goldener Funken schoss aus der Spitze hervor wie ein Feuerwerk, das tanzende Lichtflecken auf die Wände warf.	Harry took the wand. He felt a sudden warmth in his fingers. He raised the wand above his head, brought it swishing down through the dusty air and a stream of red and gold sparks shot from the end like a fire-work, throwing dancing spots of light on to the walls.	H	M
Wieder fuhren sie eine Rolltreppe hoch, und hinaus ging es auf den Bahnhof Paddington. Harry er-kannte erst, wo sie waren, als Ha-grid ihm auf die Schulter klopfte. "Haben noch Zeit für einen Imbiss, bevor dein Zug geht", sagte er.	Up another escalator, out into Paddington station; Harry only realised where they were when Hagrid tapped him on the shoulder. "Got time fer a bite to eat before yer train leaves,' he said.	N=neutral	X=filler
Hagrid half Harry in den Zug, der ihn zu den Dursleys zurückbringen würde, und reichte ihm dann einen Umschlag. "Deine Fahrkarte nach Hogwarts", sagte er. "Am 1. Sep-tember Bahnhof King's Cross - steht alles drauf."	Hagrid helped Harry on the train that would take him back to the Dursleys, then handed him an envelope. "Yer ticket fer Hog-warts", he said, First o' Septem-ber- Kings Cross- it's all on yer ticket.	N	X
Die Abteiltür glitt auf und der jüng-ste der Rotschöpfe kam herein. "Sitzt da jemand?" fragte er und deutete auf den Sitz gegenüber von Harry. "Der ganze Zug ist nämlich voll." Harry schüttelte den Kopf und der Junge setzte sich.	The door of the compartement slid open and the youngest red-headed boy came in. 'Anyone sitting there?', he asked, point-ing at the seat opposite Harry. 'Everywhere else is full'. Harry shook his head and the boy sat down.	N	X

Harry, sagte der andere Zwilling, "haben wir uns eigentlich schon vorgestellt? Freg und George Weasley. Und das hier ist Ron, unser Bruder. Bis später dann. "Tschau", sagten Harry und Ron. Die Zwillinge schoben die Abteiltür hinter sich zu.	'Harry', said the other twin, 'did we introduce ourselves ? Fred and George Weasley. And this is Ron, our brother. See you later, then.' 'Bye,' said Harry and Ron. The twins slid the compartement door shut behind them.	N	X
'Eben so', sagte er leicht verärgert. Er packte sein linkes Ohr und zog daran. Sein ganzer Kopf kippte vom Hals weg, als ob er an einem Scharnier hinge, und fiel ihm auf die Schulter. Offensichtlich hatte jemand versucht ihn zu köpfen, aber das Geschäft nicht richtig erledigt.	'Like this,' he said irritably. He seized his left ear and pulled. His whole head swung off his neck and fell on to his shoulder as if it was on a hinge. Someone had obviously tried to behead him, but not done it properly.	F=fear	M
Sie lasen ihre Briefe und ein paar Minuten herrschte Stille. In Harrys Brief hieß es, er solle wie üblich am ersten September den Hogwarts-Express vom Bahnhof King's Cross nehmen. Auch eine Liste der Bücher fürs folgende Schuljahr war enthalten.	For a few minutes there was silence as they all read their letters. Harry told him to catch the Hogwarts Express as usual from King's Cross station on September the first. There was also a list of the new books he'd need for the coming year.	N	X
Harry, Ron, George und Fred wollten zu einer kleinen Pferdekoppel der Weasleys auf dem Hügel hinter dem Haus. Sie war von Bäumen umgeben, die die Sicht vom Dorf unten versperrten, und solange sie nicht zu hoch flogen, konnten sie dort Quidditch üben.	Harry, Ron, Fred and George were planning to go up the hill to a small paddock the Weasleys owned. It was surrounded by trees that blocked it from the village below, meaning that they could practice Quidditch there, as long as they didn't fly to high.	N	X
Die Wagenräder glitten durch das flaumige Wolkenmeer, der Himmel war ein helles, endloses Blau unter der blenden weiten Sonne. Sie fühlten sich wie inmitten eines phantastischen Traums. Das ist die einzig wahre Art zu reisen, dachte Harry.	The wheels of the car skimmed the sea of fluffy cloud, the sky a bright, endless blue under the blinding white sun. It was as though they had been plunged into a fabulous dream. This, thought Harry, was surely the only way to travel.	H	X

Er bestieg seinen Besen, stieß sich vom Boden ab und sauste hoch in die Lüfte. Die kühle Morgenluft peitschte ihm ins Gesicht und weckte seine Lebensgeister. Ein wunderbares Gefühl, wieder auf dem Quidditch-Feld zu sein. Mit vollem Karacho sauste er um das Stadion und jagte Fred und George hinterher.	He mounted his broomstick and kicked at the ground, soaring up into the air. The cool morning air whipped his face, waking him effectively. It felt wonderful to be back on the Quidditch pitch. He soared right around the stadium at full speed, racing Fred and George.	H	M
Von Grauen gepackt sah Harry, wie sich der Mund öffnete, immer weiter, und ein riesiges schwarzes Loch freigab. Etwas Riesiges klatschte auf den steinernen Boden der Kammer und ließ ihn erzittern. Harry wusste, was geschah, er konnte es spüren, konnte fast sehen, wie die Schlange sich aus Slytherins Mund herauswand.	Horror-struck, Harry saw his mouth opening, wider and wider, to make a huge black hole. Something huge hit the stone floor of the chamber, Harry felt it shudder. He knew what was happening, he could sense it, could almost see the giant serpent uncoiling itself from Slytherin's mouth.	F	M
Die Schlange schlug mit dem Schwanz aus und verfehlte Harry nur knapp - er blickte ihr direkt ins Gesicht und sah, dass ihre Augen, beide großen kugligen gelben Augen, vom Phönix durchstochen worden waren; Blut floss auf den Boden und die Schlange zischte in tödlicher Qual.	The snake's tail thrashed, narrowly missing Harry, and before Harry could shut his eyes, it turned. Harry looked straight into its face, and saw that its great bulbous eyes, had been punctured by phoenix; blood was streaming to the floor and the snake was spitting in agony.	F	X
In diesem Augenblick kam Mrs Weasley in die Bar, beladen mit Einkäufen und gefolgt von den Zwillingen Fred und George, die nun ihr fünftes Jahr in Hogwarts begannen, vom neu gewählten Schulsprecher Percy und vom jüngsten Kind und einzigen Mädchen der Weasleys, Ginny.	At that moment Mrs Weasley entered the bar, laden with shopping and followed by the twins, Fred and George, who were about to start their fifth year at Hogwarts, the newly elected Head Boy, Percy, and the Weasleys' youngest child and only girl, Ginny.	N	X
Mit einem Ruck kam der Zug zum Stillstand und fernes Poltern und Krachen sagte ihnen, dass Koffer aus den Gepäcknetzen gefallen waren. Dann, ohne jede Vorwarnung, erloschen alle Lampen und sie waren jäh in schwarze Dunkelheit gehüllt.	The train came to a stop with a jolt and distant thuds and bangs told them that luggage had fallen out of the racks. Then, without warning, all the lamps went out and they were plunged into total darkness.	F	X

Der Zug fuhr weiter nach Norden und der Regen wurde stärker; die Fenster hatten ein undruchdringliches, schimmerndes Grau angenommen, das sich allmählich verdunkelte, bis schließlich die Laternen in den Gängen und über den Gepäcknetzten aufflackerten.	The rain thickened as the train sped yet further north; the windows were now a solid, shimmering grey, which gradually darkened until the lanterns flickered into life all along the corridors and the luggage racks.	N	X
Eine vermummte Gestalt. Das Gesicht war unter einer Kapuze vollständig verborgen. Harrys Blick schoss nach unten, und was er da sah, ließ seinen Magen zusammenkrampfen. Eine Hand lugte unter dem Umhang hervor und es war eine glitzernd graue, schleimige, verschorfte Hand, wie etwas Totes, das im Wasser verwest war...	A cloaked figure that towered to the ceiling. Its face was completely hidden beneath its hood. Harry's eyes darted downwards, and what he saw made his stomach contract. There was a hand protruding from the cloak and it was glistening, greyish, slimy-looking and scabbed, like something dead that had decayed in water...	F	C=control
Auf dem langen, ansteigenden Weg hoch zum Schloss wurde die Kutsche allmählich schneller; Hermine streckte den Kopf aus dem kleinen Fenster und sah zu, wie die vielen Zinnen und Türme näher kamen. Endlich machte die Kutsche schaukelnd Halt und Hermine und Ron stiegen aus.	The carriage picked up speed on the long, sloping drive up to the castle; Hermione was leaning out of the tiny window, watching the many turrets and towers draw nearer. At last, the carriage swayed to a halt, and Hermione and Ron got out.	N	X
Die neuen Schüler in Hogwarts wurden auf die Häuser verteilt. Dazu diente der Sprechende Hut, den sie aufsetzten. Professor McGonagall schritt auf ihren Platz am Lehrertisch zu und Harry und Hermine gingen so unauffällig wie möglich in die andere Richtung zum Tische der Gryffindors.	New students at Hogwarts were sorted into houses by trying on the Sorting Hat. Professor McGonagall strode off towards her empty seat at the staff table, and Harry and Hermione set off in the other direction, as quietly as possible, towards the Gryffindor table.	N	M
Harry und Ron ließen sich die Teetassen füllen und gingen zurück an ihren Tisch, wo sie den brühend heißen Tee so rasch wie möglich tranken. Sie schwenkten die verbliebenen Teeblätter, wie Professor Trelawney gesagt hatte, dann ließen sie den Tee ablaufen und tauschten die Tassen.	When Harry and Ron had had their teacups filled, they went back to their table and tried to drink the scalding tea quickly. They swilled the dregs around as Professor Trelawney had instructed, then drained the cups and swapped them.	N	X

Harry, Ron und Hermine kletterten schweigend Professor Trelawneys Leiter und die enge Wendeltreppe hinunter und machten sich auf den Weg zur Verwandlungsstunde bei Professor McGonagall. Sie brauchten so lange, um ihr Klassenzimmer zu finden, dass sie, obwohl sie früh aus Wahrsagen gekommen waren, fast zu spät kamen.	Harry, Ron and Hermione descended Professors Trelawney's ladder and the winding staircase in silence, then set off for Professor McGonagall's Transfiguration lesson. It took them so long to find her classroom that, early as they had left Divination, they were only just in time.	N	C
Er hob den Zauberstab auf Schulterhöhe, sagte "Waddiwasi!", und richtete ihn auf Peeves. Mit der Kraft einer Gewehrkugel schoss der Kaugummi aus dem Schlüsselloch und geradewegs hinein in Peeves' linkes Nasenloch; er wirbelte herum und schwebte prustend und fluchend davon.	He raised the wand to shoulder height, said 'Waddiwasi!' and pointed at Peeves. With the force of a bullet, the wad of chewing gum shot out of the keyhole and straight down Peeves's left nostril; he whirled right way up and zoomed away, cursing.	F	M
Und dann verstummte die Schar, die vorne Stehenden zuerst, und ein Schaudern breitete sich den Gang entlang aus. Die fette Dame war aus ihrem Gemälde verschwunden und das Bild mit solcher Wut zerschlitzt worden, dass Leinwandfetzen auf dem Boden herumlagen; ganze Stücke waren weggerissen.	And then a silence fell over the crowd, from the front first, so that a chill seemed to spread down the corridor. The Fat Lady had vanished from the portrait, which had been slashed so viciously that strips of canvas littered the floor; great chunks of it had been torn away completely.	F	M
Mindestens hundert Dementoren, die vermummten Gesichter ihm zugewandt, standen dort unter ihm. Es war, als würde eiskaltes Wasser in seiner Burst aufsteigen und ihm die Eingeweide abtöten. Und dann hörte er es wieder... Jemand schrie, schrie im Innern seines Kopfes... eine Frau.	At least a hundred Dementors, their hidden faces pointing up at him, were standing below. It was as though freezing water was rising in his chest, cutting at his insides. And then he heard it again...someone was screaming, screaming inside his head...a woman.	F	X

Wenn sich die Dementoren näherten, hörte er die letzten Momente im Leben seiner Mutter, ihre Versuche, ihn, Harry, vor Lord Voldemort zu schützen, und Lord Voldemorts Gelächter, bevor er sie ermordete... Harry döste ein und schreckte immer wieder hoch, sank in Träume voll feuchtkalter, verrotteter Hände und grauenerfüllten Flehens.	When the Dementors approached him, he heard the last moments of his mother's life, her attempts to protect him, Harry, from Lord Voldemort, and Voldemort's laughter before he murdered her.... Harry dozed fitfully, sinking into dreams full of clammy, rotted hands and petrified pleading.	F	X
Sie verseuchen die dunkelsten, schmutzigsten Orte, sie frohlocken inmitten von Zerfall und Verzweiflung, sie saugen Frieden, Hoffnung und Glück aus der Luft um sie her. Kommst Du einem Dementor zu nahe, saugt er jedes gute Gefühl, jede glückliche Erinnerung aus dir heraus.	They infest the darkest, filthiest places, they glory in decay and despair, they drain peace, hope and happiness out of the air around them. Get too near a Dementor and every good feeling, every happy memory, will be sucked out of you.	F	X
Bei einem Bild von der Hochzeit seiner Eltern hielt er inne. Da stand sein Vater mit dem widerborstigen, in alle Himmelsrichtungen abstehenden tiefschwarzen Haar, das Harry geerbt hatte, und winkte ihm strahlend zu. Und da war seine Mutter, Arm in Arm mit seinem Vater, und sie schwebte fast vor Glück.	He stopped on a picture of his parents' wedding day. There was his father waving up at him, beaming, the untidy black hair Harry had inherited standing up in all directions. There was his mother, alight with happiness, arm in arm with his Dad.	H	X
Dicke Büschel aus Stechpalmzweigen und Misteln zogen sich die Korridore entlang, aus den Rüstungen leuchteten geheimnisvolle Lichter und in der Großen Halle prangten die üblichen zwölf Weihnachtsbäume, an denen goldene Sterne glitzerten. Ein überwältigender und leckerer Geruch aus den Küchen wehte durch die Korridore.	Thick streamers of holly and mistletoe were strung along the corridors, mysterious lights shone from inside every suit of armour and the Great Hall was filled with its usual twelve Christmas trees, glittering with golden stars. A powerful and delicious smell of cooking pervades the corridor.	H	X

Knallbonbons!, sagte Dumbledore begeistert und bot Snape die Verschnürung eines großen silbernen Bonbons an. Snape packte es zögernd und zog daran. Laut wie ein Pistolenknall flog das Knallbonbon auseinander und es erschien ein großer spitzer Hexenhut, auf dem ein ausgestopfter Geier saß.	'Crackers!' said Dumbledore enthusiastically, offering the end of a large silver one to Snape, who took it reluctantly and tugged. With a bang like a gunshot, the cracker flew apart to reveal a large, pointed witch's hat topped with a stuffed vulture. A powerful delicious smell of cooking pervaded the corridors.	H	M
Ausnahmslos jeden Abend sah man Hermine in einer Ecke des Gemeinschaftsraums, wo sie gleich mehrerere Tische beanspruchte mit ihren Büchern, Arithmantiktabellen, Runenwörterbüchern, und mit stapelweise Ordnern für ihre ausführlichen Notizen.	Every night, without a fail, Hermione was to be seen in a corner of the common room, several tables spread with books, Arithmany charts, Rune dictionaries, and file upon file of extensive notes.	N	X
Der Dementor nimmt seine Kapuze ab, um seine letzte und schlimmste Waffe einzusetzen. Sie nennen es den Kuss des Dementors. Das tun sie denen an, die sie vollkommen zerstören wollen. Ich vermute, es ist eine Art Mund unter der Kapuze, sie pressen ihr Kiefer auf den Mund des Opfers - und saugen ihm die Seele aus.	The Dementor only lowers its hood to use its worst weapon. They call it the Dementor's kiss. It's what they do to those they wish to destroy utterly. I suppose there must be some kind ot mouth under there, because they clamp their jaws upon the mouth of the victim and - and suck out his soul.	F	M
Sprachlos trug Harry den Feuerblitz hoch zum Gryffindor-Turm. Als er um die Ecke bog, sah er den von Ohr zu Ohr grinsenden Ron auf sich zurennen. Seit einem Monat war Harry nicht mehr so leicht ums Herz gewesen.	Speechless, Harry carried the Firebolt back upstairs toward Gryffindor Tower. As he turned a corner, he saw Ron dashing towards him, grinning from ear to ear. His heart felt lighter than it had been in a month.	H	X
Das Team jubelte wie verrückt. Harry ließ den Schnatz wieder los, gab ihm eine Minute Vorsprung, dann jagte er ihm nach, wobei er sich zwischen den andern hindurchschlängelte; er sah ihn nach Katie Bells Knie lauern, drehte lässig einen Looping um sie herum und fing den Schnatz erneut ein. So gut hatten sie noch nie trainiert.	The team cheered madly. Harry let the Snitch go again, gave it a minute's head start, then tore after it, weaving in and out of the others; he spotted it lurking near Katie Bell's knee, looped her easily, and caught it again. It was the best practice ever.	H	X

Es war, als hätten sie den Quidditch-Pokal schon gewonnen. Den ganzen Tag tobte die Fete und weit hinein in die Nacht. Fred und George Weasley verschwanden für ein paar Stunden und kehrten mit Massen Butterbier, Kürbislimonade und Süßigkeiten aus dem Honigtopf zurück.	It felt as though they had already won the Quidditch Cup; the party went on all day and well into the night. Fred and George Weasley disappeared for a couple of hours and returned with armfuls of bottles of Butterbeer, pumpkin fizz and several bags full of Honeydukes sweets.	H	C
Die Osterferien waren nicht gerade erholsam. Neville Longbottom schien einem Nervenzusammenbruch nahe. Doch so viel wie Hermine hatte niemand zu tun. Meist war sie abends die Letzte, die den Gemeinschaftsraum verließ, und am nächsten Morgen die Erste, die in der Bibliothek saß.	The Easter holidays were not exactly relaxing. Neville Longbottom seemed close to a nervous collapse, and he wasn't the only one. But nobody had as much to do as Hermione. She was usually last to leave the common room at night, first to arrive at the library next morning.	N	X
Mindestens eine Woche lang schwelgte Harry im Glück. Selbst das Wetter schien ihren Pokalsieg zu feiern. Der Juni brach an, die Wolken verzogen sich und es wurde schwül, und alle hatten nur noch Lust, über die Wiesen zu schlendern und sich mit ein paar Krügen eiskalten Kürbissafts ins Gras zu fläzen.	Harry's euphoria at finally winning the Quidditch Cup lasted at least a week. Even the weather seemed to be celebrating; as June approached, the days became cloudless and sultry, and all anybody felt like doing was stralling into the grounds and flopping down on the grass with several pints of iced pumpkin juice.	H	X
Der reiche Mann, dem das Riddle-Haus inzwischen gehörte, lebte nicht hier und nutzte es auch nicht; im Dorf hieß es, er würde es aus „steuerlichen Gründen“ unterhalten, doch keiner wusste es so recht, was das heißen sollte.	The wealthy man who owned the riddle house these days neither lived there nor put it to any use; they said in the village that he kept it for 'tax reasons', though nobody was very clear what these might be.	N	X
Über den dunklen Boden des Korridors glitt etwas auf ihn zu, und als es sich dem Lichtstreifen des Feuers näherte, erkannte er mit einem Schauder des Entsetzens, dass es eine gigantische, gut vier Meter lange Schlange war. Versteinert vor Angst starrte Frank auf das Tier.	Something was slithering towards him along the dark corridor floor, and as it drew nearer to the silver of firelight, he realised with a thrill of terror that it was a gigantic snake, at least twelve feet long. Horrified, transfixed, Frank stared at it.	F	X

Er knipste die Lampe auf dem Nachttisch an, stieg aus dem Bett, durchquerte das Zimmer, öffnete seinen Schrank und blinzelte in den Spiegel an der Innenseite der Tür. Ein hagerer Junge von vierzehn Jahren schaute zurück, dessen hellgrüne Augen unter dem zerzausten schwarzen Haar leicht verwirrt dreinblickten.	He turned on the lamp beside him, scrambled out of bed, crossed the room, opened his wardrobe and peered into the mirror on the inside of the door. A skinny boy of fourteen looked back at him, his bright green eyes puzzled under his untidy black hair.	N	C
Einverstanden, sagte Harry strahlend. Er wandte sich um und ging zur Wohnzimmertür, während er gegen die Lust ankämpfte, jauchzend in die Luft zu springen. Er durfte fort... Zu den Weasleys, zur Quidditch-Weltmeisterschaft!	'OK then', said Harry brightly. He turned and walked towards the living-room door, fighting the urge to jump into the air and whoop. He was going… he was going to the Weasley's, he was going to watch the Quidditch World Cup!	H	C
Onkel Vernon schnaubte in seinen Schnurrbart. Normalerweise hätte er gefragt, was für ein Auto Mr. Weasley fuhr; andere Männer pflegte er danach zu beurteilen, wie groß und teuer ihre Autos waren.	Uncle Vernon snorted into his moustache. Normally, he would have asked what car Mr Weasley drove; he tended to judge other men on how big and expensive their cars were.	N	X
Harry und Ron verdrückten sich aus der Küche und machten sich gemeinsam mit Hermine und Ginny auf den Weg durch den engen Flur und die klapprige Treppe empor, die im Zickzack durch das ganze Haus bis hoch zu den Dachkammern führte.	Harry and Ron edged out of the kitchen, and they, Hermione and Ginny set off along the narrow hallway and up the rickety staircase that zig-zagged through the house to the upper storeys.	N	X
Mr. Weasley beschwor Kerzen herauf, denn im Garten wurde es allmählich dunkel. Es gab Nachtisch (selbst gemachtes Erdbeereis), und als sie aufgegessen hatten, flatterten Motten tief über den Tisch und der Duft von Gräsern und Geißblatt erfüllte die warme Luft.	Mr Weasley conjured up candles to light the darkening garden before they had their pudding (home-made strawberry ice-cream), and by the time they had finished, moths were fluttering low over the table and the warm air was perfumed with the smells of grass and honeysuckle.	H	M

Zu müde, um viele Worte zu wech-seln, zogen sie sich rasch an und stiegen unter Gähnen und Ächzen hinuter in die Küche. Mrs Weasley stand am Herd und rührte in einem großen Topf, Mr Weasly saß am Tisch und blätterte einen Stapel großer Pergamentkarten durch.	They dressed in silence, too sleepy to talk, then, yawning and stretching, the four of them headed downstairs into the kitchen. Mrs Weasley was stir-ring in the content of a large pot on the stove, while Mr Weasley was sitting at the table, check-ing a sheaf of large parchment ticketes.	N	X
Schließlich brannte das Feuer, auch wenn es noch mindestens eine Stunde dauerte, bis es groß genug war, um darauf etwas zu kochen. Ihr Zelt schien gleich am Fußweg zum Spielfeld zu liegen, und Leute aus dem Ministerium schritten hastig hin und her und grüßten Mr Wea-sley im Vorbeigehen höflich.	At last, they got the fire lit, though it was at least another hour before it was hot enough to cook anything. Their tent seemed to be pitched right alongside a kind of thoroughfare to the pitch, and Ministry mem-bers kept hurrying up and down it, greeting Mr Weasley cordially as they passed.	N	X
Dem Lärm nach zu schließen waren Tausende auf den Beinen, sie hörten ihr Lachen und Rufen und gelegentlich wehte Gesang an ihre Ohren. Die fiebrige Erregung war höchst ansteckend: Harry konnte nicht aufhören zu grinsen.	They could hear the sounds of thousands of people moving around them, shouts and laugh-ter, snatches of singing. The at-mosphere of feverish excite-ment was highly infectious; Har-ry couldn't stop grinning.	H	X
Jeder Zentimeter seiner Haut schien vernarbt zu sein. Der Mund war eine klaffende Wunde, die sich schräg über das Gesicht zog, und ein großes Stück der Nase fehlte. Doch es waren die Augen des Mannes, die einem wirklich Angst einjagten.	Every inch of skin seemed to be scarred. The mouth looked like a diagonal gash, and a large chunk of the nose was missing. But it was the man's eyes that made him frightening.	F	X
Sofort falteten sich die Beine der Spinne über ihrem Körper zusam-men; sie rollte sich auf den Rücken und begann unter füchterlichen Krämpfen hin und her zu wippen. Sie gab keinen Laut von sich, doch Harry wusste, wenn sie eine Stimme gehabt hätte, dann hätte sie geschrien.	At once, the spider's legs bent in upon its body; it rolled over and began to twitch horribly, rocking from side to side. No sound came from it, but Harry was sure that if it could have given voice, it would have been screaming.	F	X

Sobald die goldenen Teller leer geputzt waren, erhob sich Dumbledore von neuem. Die Halle war nun von angenehmer Spannung erfüllt. Harry fragte sich, was wohl kommen würde, und spürte ein leises, erwartungsvolles Kribbeln.	Once the golden plates had been wiped clean, Dumbledore stood up again. A pleasant sort of tension seemed to fill the Hall again. Harry felt a slight thrill of excitement, wondering what was coming.	H	C
Ihre Mitschüler brüllten vor Lachen, und selbst Fred und George stimmten mit ein, sobald sie sich aufgerappelt und ihre Bärte ausgiebig begutachtet hatten. Fred und George machten sich auf den Weg in den Krankenflügel, begleitet von Lee, der sich vor Lachen kaum auf den Beinen halten konnte.	The Entrance Hall rand with laughter. Even Fred and George joined in, once they had got to their feet, and taken a good look at each other's beards. Fred and George set off for the hospital wing, accompanied by Lee, who was howling with laughter.	H	M
Sie konnten nicht hören, was Hagrid zu Madame Maxime sagte, doch sein Blick hatte sich verschleiert und sein Gesicht hatte einen Ausdruck von Entzückung angenommen, wie Harry ihn bei Hagrid nur einmal beobachtet hatte - als er den Babydrachen Norbert betrachtet hatte.	They couldn't hear what Hagrid was saying, but he was talking to Madame Maxime with a rapt, misty-eyed expression Harry had only ever seen him wear once before - when he had been looking at the baby dragon, Norbert.	H	X
Alle winkten ihm zu, und schon von weitem sah er sie lächeln. Er flog über die Tribünen hinweg zurück, das Toben der Menge pochte in seinen Ohren, und er landete weich auf der Erde. Seit Wochen war ihm nicht mehr so leicht ums Herz gewesen.	All of them were waving at him, their smiles evident even from this distance. He flew back over the stands, the noise of the crowd pounding his eardrums, and came in smoothly to land, his heart lighter than it had been in weeks.	H	C
Harry, der es vor einer Stunde noch nicht für möglich gehalten hätte, dass er jetzt vor Glück schwebte, nahm das goldene Ei und den Feuerblitz und schlüpfte mit Ron, der wie ein Wasserfall redete, aus dem Zelt.	Picking up the golden egg and his Firebolt, feeling more elated than he would have believed possible an hour ago, Harry ducked out of the tent, Ron by his side, talking fast.	H	X

Als er sich umwandte und aus dem Gehege ging, war ihm das Herz leichter als eine Feder. Und es war nicht nur Ron... Die dort im Publikum jubelten, waren nicht nur Gryffindors. Als es darauf ankam, als sie gesehen hatten, was ihm bevorstand, waren die meisten seiner Mitschüler auf seiner Seite gewesen.	But his heart felt lighter than air as he turned to leave the enclosure. And it wasn't just Ron…those weren't only Gryffindors, cheering in the crowd. When it had come to it, when they had seen what he was facing, most of the school had been on his side.	H	X
Und tatsächlich, als sie den Gemeinschaftsraum der Gryffindors betraten, jubelten und klatschten ihre Mitschüler, dass die Wände wackelten. Sämtliche Tische und Fensterbänke trugen Berge von Kuchen und Krüge voll Kürbissaft und Butterbier.	Sure enough, when they entered the Gryffindor common room it exploded with cheers and yells again. There were mountains of cakes and flagons of pumpkin juice and Butterbeer on every surface.	H	X
Harry nahm sich etwas zu essen und setzte sich zu Ron und Hermine, er hatte beinahe vergessen, wie es war, richtig hungrig zu sein. Er konnte es immer noch nicht begreifen, dass er sich so glücklich fühlte; Ron war wieder an seiner Seite und er hatte die erste Aufgabe geschafft.	Harry helped himself to food; he had almost forgotten what it was like to feel properly hungry, and sat down with Ron and Hermione. He couldn't believe how happy he felt; he had Ron back on his side and he'd got through the first task.	H	X
Sofort war ihm klar, dass jeder Wasserstrahl eine andere Sorte Schaumbad enthielt, aber es war Schaumbad, wie Harry es noch nie erlebt hatte. Aus einem Hahn blubberten rosa und blaue Blasen von Fußballgröße, aus einem anderen quoll eisweißer Schaum, so dicht und fest, dass Harry sicher war, er würde ihn über das Wasser tragen.	He could tell at once that they carried different sorts of bubble bath mixed with the water, though it wasn't bubble bath as Harry had ever experienced it. One tap gushed pink and blue bubbles the size of footballs, another poured ice-white foam so thick that Harry thought it would have supported his weight if he'd cared to test it.	H	X
Er hatte die Maulende Myrte noch nie so gut gelaunt gesehen, außer an dem Tag, als sich Hermine mit einer Dosis Vielsaft-Trank ein haariges Gesicht und einen Katzenschwanz verpasst hatte.	He had never seen Moaning Myrtle so cheerful, apart from the day when Hermione's dose of Polyjuice Potion had given her the hairy face and tail of a cat.	H	M

Wurmschwanz schrie, schrie, als ob jeder Nerv seines Körpers brennen würde, das Schreien erfüllte Harrys Ohren, und die Narbe auf seiner Stirn entflammte vor rasendem Schmerz; auch Harry schrie jetzt laut.	Wormtail screamed, screamed as though every nerve in his body was on fire, the screaming filled Harry's ears as the scar on his forehead seared with pain; he was yelling, too.	F	C
Einen schrecklichen Augenblick lang sah Harry acht glimmende schwarze Augen und rasiermesserscharfe Greifscheren, dann war die Spinne über ihm. Sie zwängte ihn zwischen ihre Vorderbeine und hob ihn hoch; in verzweifelter Anstrengung schlug er mit den Füßen um sich.	Harry had one horrifying glimpse of eight shining black eyes, and a razor-sharp pincers, before it was upon him. He was lifted into the air in its front legs: struggling madly, he tried to kick it.	F	C
Erneut loderte ein brennender Schmerz durch Harrys Stirnnarbe, und Wurmschwanz stieß einen markerschütternden Schrei aus. Voldemort löste den Finger von Wurmschwanz' Mal, und Harry sah, dass es sich pechschwarz verfärbt hatte.	The scar on Harry's forehead seared with a sharp pain again, and Wormtail let out a fresh howl: Voldemort removed his fingers from Wormtail's Mark, and Harry saw that it had turned jet-black.	F	M
Es war ein Schmerz, der alles übertraf, was Harry je erlitten hatte; seine Knochen standen buchstäblich in Flammen; sein Kopf, fürchtete er, würde jeden Moment entlang der Narbe aufplatzen; die Augen überschlugen sich in seinem Kopf.	It was pain beyond anything Harry had ever experienced; his very bones were on fire; his head was surely splitting along his scar; his eyes were rolling madly in his head.	F	C
Der bislang heißeste Tag des Sommers neigte sich dem Ende zu und eine schläfrige Stille lag über den großen wuchtigen Häusern des Lingusterwegs. Autos, die normalerweise glänzten, standen staubig in den Einfahrten, und Rasenflächen, die einst smaragdgrün waren, lagen verdorrt und gelbstichig da.	The hottest day of the summer so far was drawing to a close and a drowsy silence lay over the large, square houses of private Drive. Cars that were usually gleaming stood dusty in their drives and lawns that were once emerald green lay parched and yellowing.	N	C
Er grinste unentwegt auf schreckliche, besessene Art umher, bis alle die neugierigen Nachbarn von ihren Fenstern verschwunden wren, dann winkte er Harry zu sich heran, und aus dem Grinsen wurde eine wutentbrannte Grimasse.	He continued to grin in a horrible, manic way until all the curious neighbours had disappeared from their various windows, then the grin became a grimace of rage as he beckoned Harry back towards him.	F	X

'Was soll das heißen?', sagte Harry erneut, doch mit einem kalten, flauen Gefühl im Magen. Gestern Nacht hatte er in seines Träumen wieder den Friedhof besucht. Dudley lachte harsch und bellend auf und nahm eine spitze, wimmernde Stimme an.	'What d'you mean?' Harry said again, but there was a cold, plunging sensation in his stomach. He had revisited the graveyard last night in his dreams. Dudley gave a harsh bark of laughter, than adopted a high-pitched whimpering voice.	F	X
Harry hörte, wie sich der Schlüssel im Schloss drehte und Onkel Vernon schweren Schrittes die Treppe hinunterging. Ein paar Minuten später hörte er Autotüren knallen, einen Motor aufbrummen und das unverwechselbare Geräusch eines Autos, das aus der Einfahrt brauste.	Harry heard the key turn in the lock and Uncle Vernon's footsteps walking heavily down the stairs. A few minutes later he heard the slamming of car doors, the rumble of an engine, and the unmistakeable sound of the car sweeping out of the drive.	N	X
'Was möchtest du, Harry?', rief Mrs Weasley. 'Haferbrei? Muffins? Räucherheringe? Speck und Eier? Toast?' 'Nur- nur Toast, danke', sagte Harry.	'What do you want, Harry?' Mrs. Weasley called. 'Porridge? Muffins? Kippers? Bacon and eggs? Toast?' 'Just - just toast, thanks. 'said Harry.	N	X
'Die Bücherlisten sind angekommen', sagte er und warf Harry, der auf einem Stuhl stand, einen Umschlag zu. 'Wird auch Zeit, ich dachte, sie hätten's vergessen, normalerweise kommen sie viel früher…'	'Booklists have arrived', he said, throwing one of the envelopes up to Harry, who was standing on a chair. 'About time, I thought they'd forgotten, they usually come much earlier than this..."	N	X
Dann öffnete er seinen Brief. Er enthielt zwei Pergamentblätter: das eine mit der üblichen Erinnerung, dass das Schuljahr am ersten September begann; auf dem anderen wurde ihm mitgeteilt, welche Bücher er für das kommende Jahr benötigte.	He then opened his letter. It contained two pieces of parchment: one the usual reminder that term started on first of September; the other telling him which book he would need for the coming year.	N	X
Dann spähte er hinüber zu Hagrids Hütte, die von diesem Fenster aus klar zu erkennen war, und da die Vorhänge zugezogen waren und aus dem Schornstein kein Rauch stieg, war ebenso klar, dass sie nicht bewohnt war.	He watched her until she became a tiny black speck and vanished, then switched his gaze to Hagrid's hut, clearly visible from this window, and just as clearly uninhabited, the chimney smokeless, the curtains drawn.	N	X

Harry riss sich das Langziehohr heraus. Sein Herz hämmerte rasend schnell und Hitze schoss ihm ins Gesicht. Er schaute zu den anderen. Die schnüre baumelten ihnen immer noch aus den Ohren und sie starrten ihn alle an. Mit einem Mal stand Angst in ihren Gesichtern.	Harry pulled the Extendable Ear out of his own, his heart hammering very fast and heat rushing up his face. He looked around at the others. They were all staring at him, the strings still trailing from their ears, looking suddenly fearful.	F	X
Die Küchentür ging auf und die ganze Familie Weasley mitsamt Hermine kam herein. Alle Sahen sie glücklich aus, und Mr Weasley, mit einem gestreiften Schlafanzug unter einem Regenmantel, ging stolz in ihrer Mitte.	The kitchen door opened and the entire Weasley family, plus Hermione, came inside, all looking very happy, with Mr Weasley walking proudly in their midst dressed in a pair of striped pyjamas covered by a mackintosh.	H	X
„Tja, das ist eigentlich alles, was ich zu sagen hatte. Ich werde Sie über die Entwicklungen auf dem Laufenden halten, Premierminister – das heißt, ich werde wahrscheinlich zu beschäftigt sein, um persönlich vorbeizukommen, aber dann schicke ich Fudge hierher."	'Well, that's really all I had to say. I will keep you posted of developements, Prime Minister-or, at least, I shall probably be too busy to come personally, in which case I shall send Fudge here.'	N	X
Ein Wecker, den Harry vor mehreren Jahren repariert hatte, tickte lauf auf dem Fenstersims, er zeigte eine Minute vor elf. Daneben war ein Bogen Pergament zu sehen, den Harry locker in der Hand hielt, bedeckt mit feiner, schräger Schrift.	An alarm clock,repaired by Harry several years ago, ticked loudly on the sill, showing one minute to eleven. Beside it, held in place by Harry's relaxed hand, was a piece of parchment covered in thin, slanting writing.	N	X
Sie schwenkte den Zauberstab über ihre Schulter; ein Laib Brot und ein Messer schwebten elegant auf den Tisch. Während der Laib Brot sich selbst in Scheiben schnitt und der Suppentopf auf den Herd zurücksank, nahm Mrs. Weasley Harry gegenüber Platz.	She waved her wand over her shoulder; a loaf of bread and a knife soared gracefully on to the table. As the loaf sliced itself and the soup pot dropped back on to the stove, Mrs Weasley sat down opposite him.	N	M

Als er Hagrid Harrys Gesicht sah, strahlte er, ohne die verdutzten Blicke der vorübergehenden Muggel zu bemerken. „Harry!" dröhnte er, und kaum war Harry aus dem Wagen gestiegen, schloss Hagrid ihn auch schon in eine knochenbrechende Umarmung.	Hagrid beaming at the sight of Harry's face and oblivious to the startled stares of passing Muggles. 'Harry!' he boomed, sweeping Harry into a bone-crushing hug the moment Harry had stept out of the car.	H	X
Das Wetter draußen vor den Zugfenstern war so durchwachsen, wie es den ganzen Sommer über gewesen war; sie fuhren streckenweise durch kalten Nebel, dann wieder in schwaches klares Sonnenlicht.	The weather beyond the train windows was as patchy as it had been all summer; they passed through stretches of the chilling mist, then out into weak, clear sunlight.	N	X
Harry winkte, bis der Zug eine Kurve genommen hatte und Mr und Mrs Weasley nicht mehr zu sehen waren, dann ging er nachschauen, wo die anderen geblieben waren. Vermutlich hatten sich Ron und Hermine in den Waggon mit den Vertrauensschülern verzogen.	Harry waved until the train had turned a corner and Mr and Mrs Weasley were lost from view, they turned to see where the others had got to. He supposed Ron and Hermione were cloistered in the prefect carriage.	N	X
„Das dachte ich auch!", entgegnete Harry. Er zermarterte sich den Kopf, wann Dumbledore ihm das erzählt hatte, aber jetzt, wo er darüber nachdachte, konnte er sich nicht erinnern, dass Dumbledore je erwähnt hatte, was Slughorn unterrichten würde.	'I thought he was!' said Harry, racking his brains to remember when Dumbledore had told him this, but now that he came to think of it, he was unable to recall Dumbledore ever telling him what Slughorn would be teaching.	N	X
Sie kehrten in den Gemeinschaftsraum zurück, der leer war bis auf ein halbes Duzend Siebtklässler, darunter Katie Bell, die als Einzige noch vom alten Quidditch-Team von Gryffindor übrig war, in das Harry in seinem ersten Schuljahr eingetreten war.	They returned to the common room, which was empty apart from half a dozen seventh-years including Katie Bell, the only remaining member of the original Gryffindor Quidditch team that Harry had joined in his first year.	N	X
„Nun hören Sie -", fing Odgen an, aber zu spät: Ein Knall ertönte, Odgen lag am Boden und hielt sich krampfhaft die Nase, und eine ekelhafte gelbliche Schmiere spritzte zwischen seinen Fingern hervor.	'Now, look -' Ogden began, but too late: there was a bang, and Ogden was on the ground, clutching his nose, while a nasty yellowish goo squirted from between his fingers.	F	X

„Du widerliche kleine Squib, du dreckige Blutsverräterin!“, brüllte Gaunt, der nun völlig die Beherrschung verlor, und seine Hände schlossen sich um die Kehle seiner Tochter. Harry und Odgen schrien gleichzeitig „Nein!“	'You disgusting little Squib, you filthy little blood traitor!' roared Gaunt, losing control, and his hands closed around his daughter's throat. Both Harry and Ogden yelled 'No!' at the same time.	F	X
Harry hatte Mundungus an der Gurgel gepackt und gegen die Wand des Pubs gedrückt. Er hielt ihn mit der einen Hand fest und zog mit der anderen seinen Zauberstab. „Harry!“, rief Hermine schrill.	Harry had pinned Mundungus against the wall of the pub by the throat. Holding him fast with one hand, he pulled out his wand. 'Harry!' squealed Hermione.	F	C
Dann, zwei Meter über dem Boden, stieß Katie einen fürchterlichen Schrei aus. Sie riss die Augen auf, aber was immer sie sehen konnte oder was immer sie empfand, machte ihr offenbar schreckliche Angst.	Then, six feet above the ground, Katie let out a terrible scream. Her eyes flew open but whatever she could see, or whatever she was feeling, was clearly causing her terrible anguish.	F	X
„Oh Percy!“ rief Mrs Weasley und warf sich in seine Arme. Rufus Scrimgeour blieb auf seinem Gehstock gestützt in der Tür stehen und lächelte, während er diese ergreifende Szene beobachtete.	'Oh, Percy!' said Mrs Weasley, and she threw herself into his arms. Rufus Scrimgeour paused in the doorway, leaning on his walking stick and smiling as he observed this affecting scene.	H	C
Sie schien den ganzen Tag besonders gut gelaunt, und abends im Gemeinschaftsraum erklärte sie sich sogar bereit, Harrys Kräuterkundeaufsatz durchzusehen (mit anderen Worten, ihn zu Ende zu schreiben).	All that day she seemed to be in a particularly good mood, and that evening in the common room she even consented to look over (in other words, finish writing) Harry's Herbology essay.	H	X
Dann breitete sich ein Lächeln auf seinem Gesicht aus. „Harry, das ist eine phantastische Nachricht! Sehr gut gemacht, wirklich! Ich wusste, dass es dir gelingen kann!“Jeder Gedanke daran, wie spät es war, schien vergessen.	Then his face split in a wide smile. 'Harry, this is spectacular news! Very well done indeed! I knew you could do it!' All thought of the lateness of the hour apparently forgotten.	H	X

Harry hatte den ganzen Vormittag lang seinen Schulkoffer komplett ausgeräumt, zum ersten Mal seit er ihn gepackt hatte. Seither hatte er zu Beginn jedes Schuljahres immer nur drei Viertel der Sachen oben herausgenommen.	Harry had spent the morning completely emptying his school trunk for the first time since he had packed it six years ago. At the start of the intervening school years, he had merely skimmed off the topmost three quarters of the contents.	N	X
Er brauchte noch eine Stunde, um ihn vollständig auszuräumen, die nutzlosen Dinge wegzuwerfen und das Übrige auf Haufen zu verteilen, je nachdem, ob er die Sachen künftig brauchen konnte oder nicht.	It took another hour to empty it completely, throw away the useless items and sort the re-mainder in piles according to whether or not he would need them from now on.	N	X
Als Harry ins Wohnzimmer trat, waren dort alle drei Dursleys ver-sammelt. Sie trugen Reisekleidung: Onkel Vernon eine rehbraune Reißverschlussjacke, Tante Petunia einen adretten lachsfarbenen Man-tel und Dudley eine Lederjacke.	When Harry reached the living room, he found all three Durs-leys. They were dressed for traveling: Uncle Vernon in a fawn zip-up jacket, Aunt Petunia in a neat, salmon-coloured coat and Dudley in his leather jacket.	N	X
'Wow', fügte er hinzu und blinzelte ziemlich schnell, als Hermine auf sie zugeeilt kam. "Du siehst großartig aus!" "Immer dieser überraschte Unterton", sagte Hermine, lächelte aber. Sie trug ein luftiges, lilafar-benes Kleid mit dazu passenden Stöckelschuhen; ihr Haar war glatt und glänzte.	'Wow,' he added, blinking ra-ther rapidly as Hermione came hurrying towards them. 'You look great!' 'Always the tone of surprise,' said Hermione, though she smiled. She was wearing a floaty, lilac-coloured dress with matching high heels; her hair was sleek and shiny.	H	X
Fred und George klatschten als Erste los, und stürmischer Beifall folgte, während die goldenen Bal-lons über den Köpfen platzten: Paradiesvögel und goldene Glöck-chen flogen und schwebten daraus hervor und stimmten zwitschernd und bimmelnd in den lauten Trubel ein.	As Fred and George led a round of applause, the golden balloons overhead burst: birds of para-dise and tiny, golden bells flew and floated out of them, adding their songs and chimes to the din.	H	X

Ginny spähte nach hinten, grinste, zwinkerte Harry zu und wandte sich dann rasch wieder nach vorn. Harrys Gedanken schweiften weit weg von dem Zelt, zu den Nachmittagen zurück, die er mit Ginny allein an lauschigen Plätzen des Schulgeländes verbracht hatte.	Ginny glanced round, grinning, winked at Harry, then quickly faced the front again. Harry's mind wandered a long way from the marquee, back to afternoons spent alone with Ginny in lonely parts of the school grounds.	H	X
Ganz anders verhielt es sich mit dem einzigen Zaubererfoto an den Wänden, einem Bild von vier Hogwarts-Schülern, die Arm in Arm dastanden und in die Kamera lachten. Harrys Herz schlug höher, als er seinen Vater erkannte.	This was in contrast to the only wizarding photograph on the walls, which was a picture of four Hogwarts students standing arm in arm, laughing at the camera. With a leap of pleasure, Harry recognised his father.	H	X
Ein schwarzhaariges Baby flog auf einem winzigen Besen ins Bild und wieder hinaus, mit schallendem Gelächter, und ein Paar Beine, die zu James gehört haben mussten, jagten ihm hinterher. Harry steckte das Foto zusammen mit Lilys Brief in seine Tasche.	A black-haired baby was zooming in and out of the picture on a tiny broom, roaring with laughter, and a pair of legs that must have belonged to James were chasing after him. Harry tucked the photograph into his pocket with Lily's letter.	N	M
Kreacher eilte mit einer großen Terrine in den Händen zum Tisch und schöpfte Suppe in blitzsaubere Schalen, während er durch die Zähne pfiff. "Danke, Kreacher", sagte Harry und begann seine Suppe zu löffeln.	Kreacher came bustling to the table with a large tureen in his hands, and ladled out soup into pristine bowls, whistling between his teeth as he did so. 'Thanks, Kreacher,' said Harry and began to spoon soup into his mouth.	N	X
Dass Hermine schmollte, konnte seine Hochstimmung nicht trüben: Ihre plötzliche Glückssträhne, das Erscheinen der geheimnisvollen Hirschkuh, die Entdeckung des Schwertes von Gryffindor und vor allem Rons Rückkehr machten Harry so glücklich, dass es ihm schwerfiel, ernst zu bleiben.	Hermione's sulkiness could not mar his buoyant spirits; The sudden upswing in their fortunes, the appearance of the mysterious due, the recovery of Gryffindor’s sword, and above all, Ron's return made Harry so happy that it was quite difficult to maintain a straight face.	H	C
Ron und Hermine strahlten immer noch. Vertraute, freundliche Stimmen zu hören war eine besondere Stärkung. Zum ersten Mal seit vielen Wochen lachte Harry: Er spürte, wie die Last der Anspannung von ihm abfiel.	Ron and Hermione were still beaming. Hearing familiar, friendly voices was an extraordinary tonic. For the first time in weeks and weeks, Harry was laughing: he could feel the weight of tension leaving him.	H	X

Ein Knall war zu hören, weißes Licht zuckte auf, und Harry brach unter qualvollen Schmerzen zusammen und konnte nichts mehr sehen. Er spürte sein Gesicht unter seinen Händen rasch anschwellen, dann kamen schwere Schritte ringsum auf ihn zu.	There was a bang, a burst of white light, and he buckled in agony, unable to see. He could feel his face swelling rapidly under his hands, as heavy footfalls surrounded him.	F	C
Harry wurde vornübergeworfen und fiel mit dem Gesicht auf die Erde. Ein dumpfer Aufprall verriet ihm, dass Ron neben ihm niedergeschlagen worden war. Sie konnten Schritte und Krach hören; die Männer warfen Stühle um, während sie das Zelt durchsuchten.	Harry was thrown, face down, on to the ground. A thud told him that Ron had been cast down beside him. They could hear footsteps and crashes; the men were pushing over chairs inside the tent as they searched.	F	X
Harry befand sich gegenüber einem Spiegel über dem Kamin, einem großen, vergoldeten Ding mit kompliziert verschnörkeltem Rahmen. Durch seine Augenschlitze sah er sein Spiegelbild, zum ersten Mal seit er das Haus am Grimmauldplatz verlassen hatte.	Harry was facing a mirror over the fireplace, a great gilded thing with an intricately scrolled frame. Through the slits of his eyes, he saw his own reflection for the first time since leaving Grimmauld Place.	N	X
Ohne Zauberstab, hilflos, wie er war, weiteten sich Pettigrews Pupillen voller Entsetzen. Seine Augen waren von Harrys Gesicht zu etwas anderem gehuscht. Seine silbernen Finger bewegten sich unaufhaltsam auf seine eigene Kehle zu.	Wandless, helpless, Pettigrew's pupils dilated in terror. His eyes had slid from Harry's face to something else. His own silver fingers were moving inexorably towards his own throat.	F	C
Ja, ja, sie hat das Baby bekommen!, rief Lupin. Überall am Tisch waren Freudenschreie zu hören, Seufzer der Erleichterung. Hermine und Fleur quiekten beide: "Glückwunsch, Glückwunsch!", und Ron sagt: "Meine Fresse, ein Baby!".	'Yes, yes, she's had the baby!' shouted Lupin. All around the table came cries of delight, sighs of relief: Hermione and Fleur both squealed, 'Congratulations!' and Ron said, 'Blimey, a baby!'	H	C
Es war ruhig, noch würde es etwas dauern, bis die Läden öffneten, und es waren kaum Käufer unterwegs. Die gewundene Pflasterstraße hatte sich stark verändert seit damals, als Harry vor seinem ersten Jahr in Hogwarts hier gewesen war und ein geschäftiges Treiben erlebt hatte.	It was quiet, barely time for the shops to open, and there were hardly any shoppers abroad. The crooked, cobbled street was much altered, now, from the bustling place Harry had visited before his first term at Hogwarts so many years before.	N	X

Ihr Zauberstab wird genügen, Mad-am, sagte der Kobold. Er streckte seine etwas zitternde Hand aus, und wie ein furchtbarer Schlag traf Harry die Erkenntnis, dass die Kobolde von Gringotts wussten, dass Bella-trix' Zauberstab gestohlen worden war.	'Your wand will do, Madam,' said the goblin. He held out a slightly trembling hand, and in a dreadful blast of realisation Har-ry knew that the goblins of Gringotts were aware that Bel-latrix's wand had been stolen.	F	X
Dann bogen sie um eine Ecke und sahen das, worauf Harry gefasst war und das sie dennoch alle erstarren ließ. Ein gigantischer Drache war vor ihnen an den Boden gekettet und versperrte den Zugang zu vier oder fünf der tiefsten Verliese von Grin-gotts.	And they turned a corner and saw the thing for which Harry had been prepared, but which still brought all of them to a halt. A gigantic dragon was tethered to the ground in front of them, barring access to four or five of the deepest vaults in the place.	F	C
Jetzt saßen sie wirklich in der Falle: Es gab keinen Weg nach draußen, außer durch die Tür, und eine Horde Kobolde schien sich auf der anderen Seite zu nähern. Harry blickte zu Ron und Hermine und sah panische Angst in ihren Gesichtern.	They were truly trapped now: there was no way out except through the door, and a horde of goblins seemed to be ap-proaching on the other side. Harry looked at Ron and Hermi-one and saw terror in their fac-es.	F	X
Alle drei begannen zu lachen, und nachdem sie einmal angefangen hatten, war es schwierig, wieder aufzuhören. Harry taten die Rippen weh, doch er sank rücklings ins Gras unter dem immer röter werdenden Himmer und lachte, bis er einen rauen Hals hatte.	All three of them started to laugh, and once started it was difficult to stop. Harry's ribs ached, but he lay back on the grass beneath the reddening sky and laughed until his throat was raw.	H	X
Konnten sie die Angst in ihrer Nähe fühlen? Harry war überzeugt davon: Sie schienen jetzt schneller heran-zukommen, atmeten auf jene schleppende, rasselnde Weise, die er verabscheute, witterten Ver-zweiflung in der Luft, waren schon dicht bei ihnen…	Could they sense fear in the vi-cinity? Harry was sure of it: they seemed to be coming more quickly now, taking those drag-ging, rattling breaths he detest-ed, tasting despair on the air, closing in…	F	C

Im nächsten Moment wurden Harry, Ron und Hermine von etwa zwei Dutzend Leuten bestürmt, die sie umarmten, ihnen auf die Schultern schlugen, ihnen die Haare zerstrubbelten, die Hände schüttelten, als ob sie gerade ein Qidditsch-Endspiel gewonnen hätten.	The next moment, Harry, Ron and Hermione were engulfed, hugged, pounded on the back, their hair ruffled , their hands shaken, by what seemed to be more than twenty people: they might just have won a Quidditch final.	H	X
Ich weiß, dass ihr euch bereitmacht zum Kampf. Einige Schüler schrien, manche klammerten sich aneinander und sahen sich voller Entsetzen nach der Herkunft der Stimme um. "Eure Bemühungen sind zwecklos. Ihr könnt mich nicht besiegen."	'I know that you are preparing to fight.' There were screams amongst the students, some of whom clutched each other, looking around in terror for the source of the sound. 'Your efforts are futile. You cannot fight me.'	F	X
Dann erschütterte eine Reihe von schweren Schlägen das Schloss, und ein mächtiger Reiterzug durchsichtiger Gestalten galoppierte an ihnen vorbei, und ihre Köpfe, die sie unter den Armen trugen, schrien im Blutrausch.	Then a number of huge bangs shook the castle, and a great cavalcade of transparent figures galloped past on horses, their heads screaming with bloodlust under their arms.	F	M
Dann hörte er einen schrecklichen Schrei, der an seinen Eingeweiden zerrte, der von Todesqualen kündete, die weder Flammen noch Flüche verursachen konnten, und er stand auf, schwankend, und hatte größere Angst als er in seinem ganzen Leben gehabt hatte.	Then he heard a terrible cry that pulled at his insides, that expressed agony of a kind neither flame nor curse could cause, and he stood up, swaying, more frightened than he had been in his life.	F	C
Angstschreie gellten durch die Luft. Die Kämpfer zerstreuten sich, Todesser wie Hogwartsianer, und rote und grüne Lichtstrahlen flogen mitten zwischen die angreifenden Monster, die schauderten und sich aufbäumten, schrecklicher denn je.	Screams of terror rent the air: the fighters scattered, Death Eaters and Hogwartians alike, and red and green jets of light flew into the midst of the oncoming monsters, which shuddered and reared, more terrifying than ever.	F	M
Und nun blickte Snape Voldemort an und Snapes Gesicht war wie eine Totenmaske. Es war marmorweiß und so reglos, dass es ein Schock war, als er zu sprechen begann und es sichtbar wurde, dass sich Leben hinter diesen leeren Augen verbarg.	And now Snape looked at Voldemort, and Snape's face was like a death mask. It was marble white and so still that when he spoke it was a shock to see anyone lived behind the blank eyes.	F	X

Der Schlangenkäfig wälzte sich durch die Luft, und ehe Snape etwas anderes tun konnte als schreien, war er mit Kopf und Schultern darin eingeschlossen, und Voldemort sprach Parsel: "Töte." Ein furchtbar-er Schrei war zu hören. Harry sah, wie Snapes Gesicht den letzten Rest Farbe verlor und weiß wurde.	The snake's cage was rolling through the air, and before Snape could do anything more than yell, it had encased him, head and shoulders, and Voldemort spoke in Parseltongue. "Kill." There was a terrible scream. Harry saw Snape's face losing the little col-or it had left.	F	M
Sein Blick war auf Etwas gefallen, das die Geräusche verursachte. Es hatte die Gestalt eines kleinen nackten Kindes, das sich am Boden krümmte, sah wund und rau aus, wie gehäutet, und lag schaudernd unter einem Stuhl, wo es zurückge-lassen worden war, unerwünscht, weggesteckt, vor Blicken verborgen und nach Atem ringend.	He had spotted the thing that was making the noises. It had the form of a small, naked child, curled on the ground, its skin raw and rough, flayed-looking, and it lay shuddering under a seat where it had been left, un-wanted, stuffed out of sight, struggling for breath.	F	X
Albus Dumbledore kam auf ihn zu, munter lächeld und aufrecht, in einem wallenden, mitter-nachtsblauen Umhang. Er schien Glück auszustrahlen wie Licht, wie Feuer: Harry hatte den Mann noch nie so vollkommen, so offensichtlich zufrieden erlebt.	Albus Dumbledore was walking towards him, sprightly and up-right, wearing sweeping robes of midnight blue. Happiness seemed to radiate from him like light, like fire: Harry had never seen the man so utterly, so pal-pably content.	H	X
Mit einem Schlenker seines Zau-berstabs ließ Voldemort den Sprechenden Hut in Flammen aufgehen. Schreie gellten durch das Morgengrauen, und als Neville lich-terloh brannte, wie zu Stein erstarrt, unfähig, sich zu rühren, konnte Harry es nicht mehr länger ertragen.	With a flick of his wand, Volde-mort caused the Sorting Hat to burst into flames. Screams split the dawn, and Neville was a flame, rooted to the spot, una-ble to move, and Harry could not bear it.	F	M
Aber James lachte nur, erlaubte seiner Mutter, ihn zu küssen, umarmte flüchtig seinen Vater und sprang dann auf den sich rasch fül-lenden Zug. Sie sahen ihn winken, dann spurtete er den Gang entlang, um nach seinen Freunden zu suchen.	But James merely laughed, permitted his mother to kiss him, gave his father a fleeting hug, then leapt on to the rapidly filling train. They saw him wave, then sprint away up the corridor to find his friends.	H	X

A.2. Skin Conductance Analysis for Study 4

The skin conductance data was collected together with the fMRI data during the experiment. The data was trimmed (to the starting point of the data identical to that of the fMRI data), pre-processed, and analyzed with SCRalyze (Bach, Flandin, Friston, & Dolan, 2009, 2010). Event-related GLM analyses with the same design matrices used for Study 4 in Chapter 5 were conducted. The following comparisons were performed:

1) The main effect of language: L1 minus L2
2) The main effect of fear: Fear minus Neutral
3) The main effect of happiness: Happy minus Neutral
4) Interaction for fear: [Fear-L1 minus Neutral-L1] minus [Fear-L2 minus Neutral-L2]
5) Interaction for happiness: [Happy-L1 minus Neutral-L1] minus [Happy -L2 minus Neutral-L2]

t-statistics are shown in Table A.2.1 and Figure A.2.1. dfx = 19.

Results showed significant main effect of fear, which is in line with the amygdala activation (Table 5.4). For the interaction effects, the interaction for fear was significant (instead of happiness for the fMRI data). The pattern of interaction showed larger SCR when reading fear-inducing passages in L2 vs. in L1. Note that the SCR is generally stronger when reading in L2 than in L1 (though insignificant), the SCR results might have confounded with the higher cognitive demand when reading passages in L2 (Botvinick & Rosen, 2009; Mehler, Reimer, & Coughlin, 2012; Reimer & Mehler, 2011).

Table A.2.1. t-statistics of GLM analyses of SCR

Contrast Name	t	p
L1 - L2	-0.90	0.3775
Fear - Neutral	2.70	0.0143*
Happy - Neutral	1.01	0.3235
Stronger Fear in L1	-2.61	0.0174*
Stronger Happy in L1	-0.07	0.9488

*p < 0.05

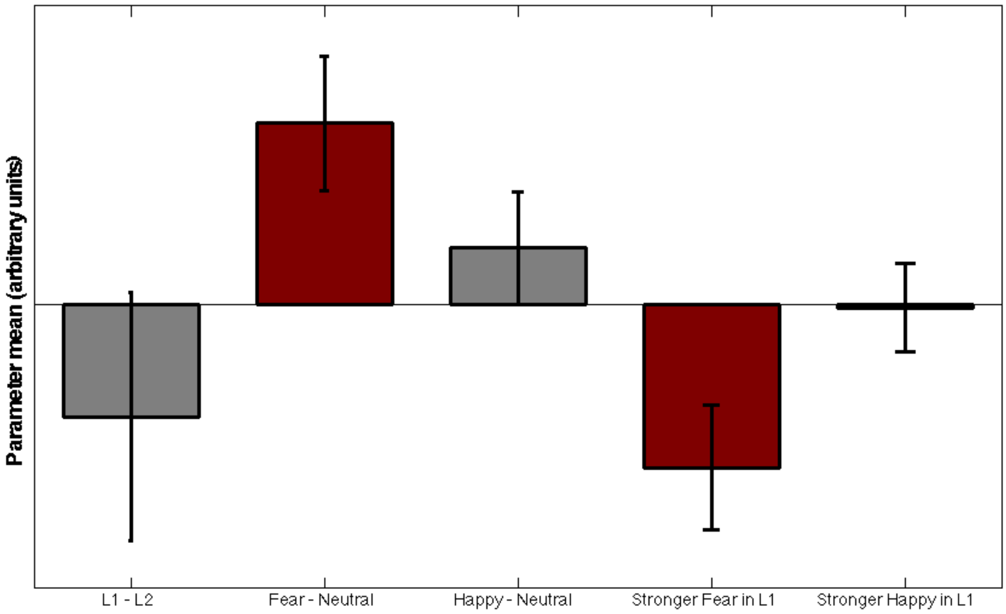

Fig. A.2.1. t-Statistics of GLM Analyses of SCR in Study 4

CURRICULUM VITAE

Der Lebenslauf ist in der Online-Version aus Gründen des Datenschutzes nicht enthalten.

Eidesstattliche Erklärung

Die Studien dieser Dissertationsschrift wurden in marginal modifizierten Versionen in internationalen Fachzeitschreiften veröffentlicht oder stehen kurz vor der Einreichung:

Studie 1:

Hsu, C.-T., Jacobs, A.M., Citron, F.M., and Conrad, M. (under review). The Emotion Potential of Words and Passages in Reading Harry Potter - An fMRI Study.

Studie 2:

Hsu, C.-T., Conrad, M., and Jacobs, A.M. (2014). Fiction feelings in Harry Potter: haemodynamic response in the mid-cingulate cortex correlates with immersive reading experience. *NeuroReport*. [Epub ahead of print] doi: 10.1097/WNR.0000000000000272.

Studie 3:

Hsu, C.-T., Jacobs, A.M., Altmann, U., and Conrad, M. (under review). "The magical activation of left amygdala when reading Harry Potter: An fMRI study on how descriptions of supra-natural events entertain and enchant".

Studie 4:

Hsu, C.-T., Jacobs, A.M., and Conrad, M. (2015). Can Harry Potter Still Put a Spell on us in a Second Language? An fMRI Study on Reading Emotion-laden Literature in Late Bilinguals. Cortex 63, 282-295. doi: 10.1016/j.cortex.2014.09.002.

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbständig und ohne unzulässige Hilfe verfasst habe. Die angeführten Ko-Autoren können bestätigen, dass ich für die im Rahmen der Promotion durchgeführten Studien und die Erstellung der Fachartikel hauptverantwortlich war. Die Arbeit ist in keinem früheren Promotionsverfahren angenommen oder abgelehnt worden.

Berlin, den 13. Oktober 2014
Chun-Ting Hsu