EMBODIED EMOTION:

THE ROLE OF BODILY FEEDBACK IN EMOTION COMPREHENSION

AS SEEN IN LANGUAGE

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Abstract

The current project explores the nature of embodiment, specifically how affective associations of physical posture interact with emotion in language. Previous research has established that perceptual and motor information is encoded alongside semantic representation, and physical feedback is used to support cognition. Evidence suggests that emotion is also embodied. Muscle feedback from the face is used to support recognition of valence in language. Observational studies also show that open and slumped body posture are associated with positive and negative emotion, respectively. However, little research investigates experimentally induced posture. Additionally, research typically employs self-referent and autobiographical language with little consideration for experimental control over language stimuli. The current projects makes important steps toward developing and validating controlled linguistic materials for emotion research. Further, the project aims to extend previously observed facilitation from facial feedback to the full body.

Three repeated measures experiments compared the effects of open and slumped posture on three cognitive measures: explicit recognition of valence from sentences, memory of affective details from sentences, and memory from text. Results indicate that positive, but not negative or neutral sentences are susceptible to the influence of posture. Interestingly, explicit processing of emotion, i.e., recognising valence, was inhibited by open posture, while implicit access during the memory task revealed the classic facilitation effects proposed by embodiment research. Body feedback did not affect comprehension and memory from full text. These results are discussed in relation to three main claims. First, embodiment of emotion is observable in sentence processing, although potentially limited to specific valence types. Second, explicit and implicit processes require different levels of activation, and implicit, automatic access that does not involve conscious awareness of the emotive content is more reflective of the neural priming effects proposed by embodiment models. Third, the linguistic and conceptual complexity of longer text formats preclude embodied effects due to increased confounds from visual imagery, metaphor and other processes that do involve perceptual and sensory information, but not internal bodily feedback, and are thus not susceptible to the posture manipulations employed here.

Finally, implications for future research involve continued validation and refinement of the language materials used for emotion research, with additional consideration for concreteness and imagery ratings, as well as embodied properties on the word level. Research should also consider exploring the bidirectional interplay between language and posture further.

Contents

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Declaration

I declare that the work submitted in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the Faculty of Health and Life Sciences Ethics Committee at Northumbria University between March 2017 and June 2019.

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1. Chapter I. The nature of embodiment – overview of literature and links to affective language

Emotion has an integral role in human culture, inspiring art, literature and progress. As such, it is closely linked to these social and linguistic domains – we use speech and writing to communicate every day, and a good proportion of such language contains reference to emotion. Expressing this content effectively and understanding the mood, emotions and intentions of others are key for communication (Nygaard & Queen, 2008).

However, emotion is also associated with other aspects of our human experience, namely our body. We '*rise* to success' and '*embrace* new possibilities', we are '*weighed down* by responsibility' and '*brought to our knees*' by sadness. These expressions are not only a normal part of everyday language use, but also reflect a deeper, conceptual bond, where the idea of sadness is inherently associated with the feedback it brings – the hunched, weighed-down physical response that expresses this feeling. Previous literature has explored the metaphorical nature of such linguistic expressions, and argued that much of metaphor is built upon associations with the physical world, such as space and direction, the environment and internal awareness of the body (Lakoff & Johnson, 1980a; Lakoff & Johnson, 2003). However, it is necessary to explore whether this relationship exists beyond metaphor, and to what extent emotive language is understood through physical states. The current doctoral project will investigate the embodiment of emotion as seen in language, and aims to establish whether bodily feedback during a language task affects the ability to correctly identify the emotion category of sentences, and recognise key affective details from sentences and text.

To explain the foundation for these assumptions, the current review of the literature will discuss three main lines of evidence. First, it will establish the nature of embodied cognition, specifically the notion that cognitive states are inherently associated with relevant physical experience, and are influenced by situated perceptual input and internal feedback from the body. Consistent with main theories of embodiment (Barsalou, 2008; Glenberg, 2010), it is assumed that even abstract higher-order processes such as language comprehension and semantic processing involve access to available physical information, and thus can be facilitated by it. Second, the current review will discuss the embodiment of emotion, and argue for a dichotomy of positive and negative affect which consistently demonstrate distinct associations with body posture. Lastly, emotion in language will be discussed, specifically areas of particular interest, and the importance of refining language items used in embodiment research. This then leads to the general aims of the current project.

1.1. Embodied Cognition

1.1.1.Framing the debate – modularity and embodiment

Embodied cognition is a moderately recent development in cognitive psychology, with potentially revolutionary implications. Previously, the mind was viewed as an abstraction, its processes mysterious and separate from physical experience. The philosophical underpinnings of this perspective originate from the Mind-Body dualism proposed by Descartes (1984), suggesting that cognition is separate from the physical form. A philosopher of the mind, Descartes frames many debates on the nature and source of human consciousness (Descartes, 2000). While there is some disagreement whether modern-day interpretations differ from the original (Alanen, 1989), Cartesian dualism has substantial implications for 20th century theories of psychology. Wee and Pelczar (2008) discuss the contemporary definitions of dualism, and differentiate between the original postulates that mental representations do not necessarily correspond to physical objects, and the potentially bolder claims of modal dualism, stating that mental representations or 'worlds' do not necessarily contain every entity of the real world, and that physical entities are not sufficient to explain the nature of thought and reason.

This view dominates the cognitive field over past decades, and culminates in the theories of modularity. As Wilson (2002) summarises, traditional models of cognition consider it to be a primarily abstract process, where perceptual input and output are separate from central cognitive functions. Fodor (1983) states that mental representation for perceptual input is limited, while available abstract representations are multiform. Fodor also claim that abstract and physical representations are not equally accessible, where the lower levels, i.e., perceptual, are too automatic and too quickly transformed into higher-order codes to be directly accessed by the cogniser. As discussed by Wilson (2002), Fodorian modularity postulates that the systems which deliver input from the environment are modular in nature, limited and separated from other mental processes, including reasoning and judgments. Based on this account, systems that interact with the environment are not only subservient to abstract processes, but also encapsulated and thus not overlapping with them.

Importantly, this also applies to language. Modularity claims that meaning and grammar codes are abstract processes, and thus language comprehension, judgment and decision making are separate from perceptual codes (Fodor, 1983). Chomsky (1995) continues to develop this view – while cognition and language are connected to nature and limited by experience of the world, they are not bound to mechanical and motor experience. Therefore, a cogniser needs to have encountered the concept of green, grassy fields in order to understand it, but this concept exists outside of body and matter. Chomsky contradicts the so-called '*mechanical philosophy*', claiming that conceptual comprehension does not depend on embodied functionality. In this view, cognition starts with a limited physical representation – the brain and the world it is placed in, but results in unlimited, unconstrained mental representations (Chomsky, 2006). To summarise, modularity poses that perceptual and physical systems and their access to cognition are limited, while central, abstract processes are infinite and are what constitutes 'the mind'. While later updates of this model acknowledge that language interacts with the environment and with sensory-motor experience, this is still defined as broad categorisation, and not the main focus of attention. Narrow language systems, including understanding of ideas and emotions, are discussed as abstract and isolated from other systems (Hauser, Chomsky & Fitch, 2002).

This perspective, once dominant in the cognitive field, has received contention in recent decades, sparking a debate particularly focused on reasoning, comprehension and language (Barrett & Kurzban, 2006). Recent views argue against the classic position that abstract and perceptual codes are separate. Even proponents of Fodorian modularity (Chiappe, 2000) suggest that evidence for multimodal integration argues against a fully encapsulated account for cognition, where mapping visual input onto emotional meaning is a frequent, if not inherent part of metaphor and language. There is increasing push for a multidisciplinary approach to cognition, where evolutionary development of thought, reason and language needs to be considered (Plomin, Samuels, Sperber and Stich, 2000).

This debate may be explained by the different definitions of physical experience, where modularity discusses purely perceptual mechanisms such as seeing shapes in vision or utterances and sounds in language (Fodor, 1983), while embodied literature frames the physical in terms of experience, association and meaning (Barsalou, 2008) – processes that could almost be called semantic. In this light, perhaps the suggestions of grounded mental states do not differ so starkly from the natural cognition discussed by Chomsky (2006). These perspectives, seemingly in absolute opposition, may need to be recontextualised with one key differentiation – whether 'physical' refers to perceptual input only, i.e., spectra of light forming images and sounds forming words, or is redefined as experience and knowledge gained through the senses. This leads to the main postulates of embodiment.

1.1.2. Theories of embodied cognition

Recent decades have seen increased support for the idea that cognition is, in fact, linked to physical experience and thus to the body and its states. This perspective is primarily based on the early works of William James, who discusses the philosophy of the mind and consciousness as connected to the physical world (James, 1885; James, 1890). However, implications for language were mostly popularised by Lakoff and Johnson, who discuss the nature of metaphors as conceptual knowledge based on real-world physical elements (Lakoff & Johnson, 1980a). They argue for the scientific principles of embodied realism (Lakoff & Johnson, 1999), and continue to develop this view to account for how mental representations, or schema, are formed. This is framed by the debate between rationalist and empiricist scientific views, where rationalists suggest that knowledge is gained independently from experience, and empiricism claims that experience, including sensory input, help support mental representations (Markie & Folescu, 2004). In response, embodied realism argues for a mixed approach, where schemas are gained through a combination of internal and external representations (Lakoff & Johnson, 2003). In summary, embodied realism does not argue against purely abstract mental representations, but highlights that experience is at least partially responsible for the formation of mental imagery and consequent mental operations. This leads to a re-evaluated perspective on the mind and the body – while the brain controls the body and its perceptual mechanisms, it also learns from those physical experiences, forming a bidirectional interplay (Glenberg, Witt & Metcalfe, 2013).

One of the strongest proponents of embodiment is Glenberg. Contrary to philosophical suggestions by Cartesian dualism and Chomsky's modular view of language, Glenberg (2015) proposes that the human psyche originates much the same as animal awareness, from experience of the world and continuous evolution. Glenberg suggests that cognition is deeply intertwined with sensorimotor systems in particular, and this extends to any mental process, included functions previously assumed to be entirely abstract, such as comprehension and language. Further, embodiment is proposed as a unifying factor, providing the necessary links between perception, thought and action (Glenberg, 2010). Prinz (1987) supports this claim, describing cognition as a process of linking perception, action and ideas toward a shared goal.

Another key implication of embodiment is mental models constructed from experience (Glenberg, 1997). Such models are implicated in learning, with conceptual knowledge built to answer the requirements of learning a new environment (Seel, 2001). Glenberg and Kaschak (2003) discuss how perception and action are encoded and later re-activated to form meaning and a mental picture. Zwaan continues to develop the theory of mental models and their importance for narrative comprehension. When hearing or reading a story, the reader formulates a situated model of the characters, places and actions portrayed (Zwaan, 1999) – *situated* in the event, objects and physical-spatial relationships depicted. Importantly, the depth and detail of such models depends on experience. Zwaan suggests that a reader with physical experience would form a richer mental representation than a novice. While novices are able to reconstruct the main ideas based on description alone, experienced participants also activate personal knowledge. Taylor and Zwaan (2013) discuss this as *fault-tolerant* cognition – comprehension is possible even within partially unavailable or incomplete information, however with costs in speed and detail.

This demonstrates one of the key mechanisms of embodiment, discussed across theories and research – simulation. In embodiment research, *simulation* refers to re-experience of previously acquired knowledge. While modularity discusses perceptual systems as separate from higher-order cognition, and assumes knowledge is encoded in abstract symbols (Fodor, 1983), embodiment attempts to bridge that gap. The work of Barsalou is central to these efforts. Barsalou discusses cognition in terms of perceptual symbols, and argues that perception is an inherent fundament of cognitive understanding (Barsalou, 1999). Specifically, he argues that symbols used to store and reactivate knowledge are, in fact, modal in nature, and originate from physical experience. Thus, objects and states experienced through the senses become schemas represented neurally, stored in long-term memory and activated for conscious access. Barsalou further states that such systems are conceptual in nature, supporting understanding and helping to build complex symbols out of more basic ones. This includes visual, haptic and interoceptive feedback, suggesting that information from internal bodily systems as well as external perception is stored and incorporated into conceptual representations. While this view contradicts many classic models of cognition, it also gathers increasing support from neuroscience and other areas of psychology, and is likely to continue providing further research exploring this debate (Barsalou, 2010). However, Barsalou's early perspective is primarily focused on perceptual input. Further updates redefine cognition as *grounded*, where embodiment is only one source of feedback, alongside visual imagery of objects, associated actions and sensations, and mental simulation (Barsalou, 2008). This reaffirms the multimodal nature of cognitive simulation, with equal importance of external and internal information allowing for abstract cognition to arise from this rich, situated feedback.

This summarises some of the main tenets of embodied cognitive theories. For the purpose of this review, the terms *embodied*, *situated* and *grounded* are used interchangeably to discuss cognitive processes based on physical and other perceptual experience. Per Wilson's review of the area (2002), some of the main claims of embodiment are that cognition is situated within the environment, and this already available environmental information is used to support understanding, especially under time pressure. Cognitive effort is thus reduced by relying on automatic reactivation and simulation of this feedback – abstract processes understood more quickly due to associations with action. The importance of this overlap is demonstrated in embodiment research.

1.1.3. Support from data – affordances, neural correlates and language

One of the main lines of evidence for an interplay between motor actions, the environment and cognitive states comes from affordances research. Gibson (1977) introduces the concept of affordances and describes them as the possible uses or applications of an object seen in the environment. They refer to what the object allows, or *affords*, one to do. Thus, if one sees a chair, the most immediately available affordances are sitting on it, leaning on it, or using it to stand on to reach a high shelf. While there are many day-to-day examples of this process, affordances have important implications for cognition. Due to the overlap of action and interaction with environmental stimuli, affordances are an example of grounded cognition. Gibson (2014) argues against the stimulus-response interpretation of cognition, where perceptual input and motor reaction are both more-or-less severed from cognitive awareness (Fodor, 1983). Instead, Gibson describes an interplay between perception and action, and claims that conceptual representations of an idea or an object are built from perceptual experience, which is consistent with other perspectives of embodiment such as Barsalou (1999, 2008) and Glenberg (2010, 2015).

Tucker and Ellis (2001) present some of the seminal evidence for affordances. They investigate motor responses to objects with two contradictory affordances – power grasp and precision grasp. The power grasp involves the full palm, for example the motion used to pick up the handle of a hammer. The precision grasp involves pinching with the front fingers, such as holding a pen. In a series of experiments participants were asked to view objects and categorise them as natural or manufactured using a device that mimics both a precision and a power grasp, without directly resembling any familiar objects from daily life. Importantly, participants are not required to consciously evaluate the 'graspability' of the objects. However, Tucker and Ellis demonstrate that these hand affordances were activated automatically, and interfered with performance, where categorisation of graspable object is slower when for a pinching response, and vice versa.

Similar effects were found when participants were asked to judge object orientation only, i.e., upright or downturned (Tucker & Ellis, 1998) or respond to an auditory stimulus, and not directly categorise the object (Ellis & Tucker, 2000), suggesting that physical properties of the stimulus are accessed on an unconscious level even when no evaluation or awareness of the object's nature is required. Further, the interaction between affordances and motor response is observed even when an object is no longer visually present on the screen, and when memory is degraded (Tucker & Ellis, 2004), supporting the automatic and lasting nature of motor priming. It is important to note that *potential* actions, unlike observed or executed actions, form a mental schema of the object and its possible uses, thus access to affordances indicate that motor properties may be accessed as early as visual perception and object identification, and not only as a response to action planning, supporting the claim that visual and motor codes interact (Barsalou, 2008).

Hand-based affordances are also associated with memory of shapes. In a series of experiments, Taylor and Zwaan (2010) demonstrate that responses to spherical shapes depends on the size of the visual object and its 'graspability'. Responses provided by pressing a spherical object are influenced by the physical characteristics of round visual object, suggesting that visual and motor information interact during semantic comprehension processes, such as object and colour identification. As Greeno (1994) discusses, the interaction between mental schema for an object and its physical representation involves increased awareness of its properties, its affordances and constraints, i.e., what it allows to do and what it does not. Thus, viewing a non-graspable object inhibits mental processing and physical grasp responses, indicative of an automatic link between the physical properties of the world and mental processes.

The overlap between affordances and speed of response can also be localised in the brain. Grèzes, Tucker, Armony, Ellis and Passingham (2003) used a paradigm where large and small objects were presented and participants were asked to categorise them as man-made or natural. Importantly, large objects can be grasped with a wider grip, or a power grip, while small objects are held with a precision grip. The study observed that performance was faster in a congruent condition, where a power response was made to a large object. Further, making judgments activated a network of parietal, pre-motor and inferior frontal areas. Activation was stronger when a precision-grip response was paired with a power-grip object, i.e., the incongruent condition. Therefore, assessing an object's affordances recruits the motor cortices, and the strength of the activation depends on priming versus competition. Incongruence demands greater neural resources, possibly due to simultaneously activating two competing representations. These resources were accessed automatically, as the task did not ask participants to consciously evaluate the 'graspability' of objects, and were localised in motor areas. The results suggest that viewing and processing objects recruits some of the same brain structures as motor actions, and that the motor characteristics of said objects are processed even during supposedly abstract evaluative judgments. Moreover, this overlap can prime a response and improve performance, otherwise known as facilitation, or reduce performance, known as inhibition.

This is consistent with the proposition of a distributed model of brain resources available for perceiving, understanding and performing actions (de Wit, de Vries, van der Kamp & Withagen, 2017). The data also supports one of the important principles of embodiment – the claim that facilitation and inhibition, and their basis in conceptual overlaps, occur on the neural level (Barsalou, 2008, Glenberg, 2015). Sporns (2010) conceptualises the mind-body link as information gained through the environment influencing the brain, which in turn guides further access to external input and interaction, and discusses evidence for anatomical and functional overlaps between perceptual systems in the brain and areas related to cognitive control. Embodied representations of the self, such as physical location and state, are also accessed while performing mental imagery, and localised in the temporo-parietal extrastriate body area, which are both implicated in monitoring bodily feedback.

The observed neural overlaps have important implications for language as well. Hamzei et al. (2003) observe neural activation during motor action and production of verbs, and demonstrate a shared network for processing verbs and physical actions, in particular the parietal cortices and the left inferior frontal gyrus (IFG), i.e., Broca's area. Pulvermüller (2010) suggests that even advanced linguistic processes such as grammar involve access to brain networks shared with embodied representation. Broca's area is mostly associated with phonological processes and lexical retrieval (Amunts et al., 2004). However, the left inferior prefrontal region as a whole has also been linked to semantic processes (Devlin, Matthews, & Rushworth, 2003). Perhaps most importantly, this area provides controlled retrieval of semantic information (Wagner, Paré-Blagoev, Clark, & Poldrack, 2001) and is activated more strongly by selection between competing words (Thompson-Schill, D'Esposito & Kan, 1999), suggesting the area would be engaged by tasks that require making fine-grained distinctions in word meaning. While the IFG does not directly store semantic representations (Binder, Desai, Graves & Conant, 2009), it appears to offer top-down access to representations stored in temporoparietal regions (Binder & Desai, 2011). This involvement in retrieval and selection suggests that conceptually-heavy tasks that involve judgments, decision making and rich semantic access to words would be more strongly reliant on the aforementioned brain network. Evidence suggests that access to action verbs activates distinct subsystems within Broca's area and motor cortices (Kemmerer, & Gonzalez-Castillo, 2010). This supports the notion that neural processing of motor behaviours overlaps not only with cognitive processes as a whole, but specifically with language and semantics.

Kan, Barsalou, Olseth Solomon, Minor and Thompson-Schill (2003) observed modal, perceptual representations of word pairs when the language task requires semantic access, and not only associations based on frequency. Specifically, the study found neural activation in the left fusiform gyrus, consistent with assessing the visual properties of a stimulus. Thus, visual information is accessed for comprehension even when the object is presented verbally, supporting the perceptual symbol overlap proposed by Barsalou (1999). Processing language items across perceptual modalities, i.e., visual and auditory, is slower than responses within modality (Pecher, Zeelenberg & Barsalou, 2003), suggesting that physical information and imagery are accessed automatically.

Further, the spatial representation of images is accessed during verbal tasks, where horizontal and vertical axis of images influence reaction time on corresponding sentences (Richardson, Spivey, Barsalou & McRae, 2003). In fact, spatiotemporal mappings of concepts is one of the oldest proposed examples of embodiment. Lakoff and Johnson (1980, 2003) discuss many examples of metaphorical language grounded in spatial or physical experience, including conceptual parallels such as '*the mind as a machine*' and '*the mind as a container*' or '*understanding is seeing'*, but also purely spatial associations such as 'good is up' or '*rational/lofty/ideological is up*'. Concepts, including abstract ideas such as thought, feeling, language and morality, are mapped onto dimensional axes. This is proposed to occur on a neural level, where the encoding of language provides an accessible bridge between the functional purpose of different brain areas (Kemmerer, 2006).

Importantly, conceptual overlaps are semantic in nature. Many claims of grounded cognition hinge upon the implicit assumption that semantic associations are automatically accessed during language comprehension. Early evidence demonstrates that semantics are accessed even during lexical decision tasks (Fischler, 1977), even though lexical and phonological information are traditionally claimed as earlier and easier processes, with semantics requiring effortful attention. Joordens and Becker (1997) also report that increasing the semantic demands of the task, such as requiring finer distinctions in meaning, leads to more prominent priming even on the lexical level. In addition, when lexical decision tasks involve phonologically legal, pronounceable distractor words, concrete words are processed faster than abstract (James, 1975). Concreteness includes physical, visual and other experiential sources of input, thus suggesting that embodied associations facilitate semantic access.

While there are some debates on the presence and extent of embodiment in semantics, consistent support seems to favour a mixed approach between the modular and situated perspectives. Damasio (1989) argues for a distributed neural network that includes highly specialised modal systems, but also convergence zones, which offer integration and binding of information from multiple modalities (Binder & Desai, 2011). Meteyard, Cuadrado, Bahrami and Vigliocco (2012) agree with this interpretation, suggesting that semantic access recruits a mix of resources.

Vigliocco and Vinson (2007) present one of the most well-known theoretical accounts for semantic representation, and claim that concepts, i.e., idea or schemata, are closely mapped onto word meaning, even if not equivalent to it. While the authors review purely conceptual, abstracted methods of deriving word meaning or building word associations and clusters, such as frequency and linguistic cooccurrence, they indicate that external experience also contributes to understanding of concrete concepts. Thus, interaction with the world offers one of the main sources of information encoded in language representations (Vigliocco, Meteyard, Andrews & Kousta, 2009), further supporting the claims of embodiment research.

1.1.4. Implications

The impact of embodiment ranges across a wide variety of behaviour, perception and comprehension. Barsalou, Niedenthal, Barbey and Ruppert (2003) discuss: embodiment of social concepts, such as approval, success/failure and social relationships; embodiment of mimicry and empathy, such as understanding thought from the body or repeating physical behaviour observed in others; and embodiment of positive and negative affect, all of which observable in performance. Soliman, Gibson and Glenberg (2013) demonstrate that embodiment has a role in social identity and culture belonging, where in-group and out-group categories are represented in terms of spatial relations. This once again highlights how situated and embodied associations can help indicate social belonging, approval, as well as emotion.

Broadly, what remains to be seen is whether social constructs such as approval or 'goodness' are embodied through mechanisms that rely on emotion, i.e. events that are 'good' eliciting positive affect and thus corresponding physical states. Emotion and perceived levels of pleasantness have an integral role in understanding social feedback and producing social behaviours. When we perform poorly and receive negative feedback, we feel negative affect and react by ‘hunkering down’, thus forming a pairing between the unpleasant feeling and the posture associated with it. This highlights a strong link between emotional reaction to the environment and the corresponding physical behaviour, including within social context. Further, emotion and its links to body physiology are one of the key mechanisms of embodiment proposed by Glenberg (2015). Therefore, it could be argued that exploring the situational and physical grounding of emotion is necessary for understanding the nature of embodiment and neuro-cognitive processes behind it.

1.2. Embodied emotion

1.2.1. Theories of embodied emotion – James-Lange, Prinz and beyond

Embodiment proposes that the physical world interacts with cognitive processes such as language and emotion. As summarised by Prinz (1987), thought and action are united by experience. Further, Prinz (2005) discusses emotions as sensorimotor awareness of bodily changes, and as a complex form of perceptual and semantic representations (Prinz, 2006). This is consistent with the James-Lange philosophical model of emotion (James, 1884; Lange, 1885) which is one of the earliest founding perspectives on the embodiment of cognition and affect alike. James (1884) proposes that emotion processing in the brain can result in response to events experienced on the physical level, and is thus associated with physiological activation, such as the autonomic nervous system. Prinz (2005) agrees with this view, claiming that emotions are, in fact, perceptions of bodily changes, and discusses emotion as a form of sensory perception not much different from vision. Overall, the philosophical stances adopted by James-Lange and Prinz agree that affective processing in the brain overlaps with sensory feedback from internal, physiological states.

Other early models discuss the difficulty in defining emotion and identifying the threshold at which activation, whether mental or physical, becomes feeling (Schlosberg, 1954). Schlosberg reviews three main conceptual models of emotion: as thought, as the interplay between feeling and theemotion associated musculoskeletal and physiological feedback from it, and as levels of activation. While such models may differ in exact focus, they acknowledge the body as a relevant source of affective information, and part of the process through which emotion is encoded.

Ellsworth and Scherer (2003) discuss emotion as the result of cognitive appraisals of situation, cause, motivation. Scherer (2005) claims that emotion can be characterised by the cause, i.e., responding to an event or the memory of an event, and the appraisal, i.e., evaluation of the event or object and its relevance to the perceiver. Further, Scherer suggests that emotions are not static and change rapidly to adapt to the circumstances. Appraisal theories (Scherer, 1999) propose that these ongoing evaluations of the situation and its relevance underpin emotion, where continuous 'checking' of internal motivations and external events provides an adaptive mechanism for the emergence of emotional states (Scherer, Schorr & Johnstone, 2001). Other criteria for appraisal are agency, i.e., behaviours attributable to the self or to others, control over the situation, and discrepancy between one's own intentions and the events (Moors, Ellsworth, Scherer & Frijda, 2013). Thus, both motivation and assessment of the external world are key.

Frijda (2004) links this to action, where a key function of emotion is goal-oriented behaviour. Broadly, emotion is defined as evolutionary in nature, promoting awareness of the body's signals, internal monitoring and relevant actions. This is consistent with Glenberg's suggestions of cognition as a vital interplay between emotion and sensorimotor systems for the purpose of survival (Glenberg, 2015). Evolution requires interaction between the organism and the environment, and human cognition provides this by combining physical feedback and awareness (Glenberg, 2010). Importantly, this involves affective and social environments as well as communication in general, thus implicating embodied emotion in many aspects of human culture.

Bradley and Lang (2000) continue to define emotion as part of a system that incorporates reaction to the environment and physical response through the body. This system ranges from physiological expressions, i.e., visceral and muscular, to behaviour and language. Broadly, this leads to a categorisation of positive emotion as approach-based, moving toward pleasant and favourable stimuli, and negative emotion as withdrawal from threats.

Pleasantness is another dimension through which emotion can be categorised, where affect is defined by high intensity and pleasure/displeasure (Cabanac, 2002). Russell (1980) proposes the Circumplex model of affect, which identifies eight dimensions of emotion: pleasure, excitement, arousal, distress, displeasure, depression, sleepiness and relaxation. The model arranges these along two axes, originally labelled 'arousal/sleepiness' and 'misery/pleasure'. Participants were asked to place emotion words in the resulting four quadrants, for example the word 'delighted' placed in the quadrant between 'pleasure' and 'excitement'. Thus, the 'arousal' and 'pleasantness' axes group emotions based on the level of excitement and the valence, where 'valence' refers to positive, negative or neutral emotional content.

1.2.2. Data on embodied emotion

Interestingly, research has argued that the approach/avoidance of emotion may be based on representation of self in space (Markman & Brendl,2005), and thus a complex interplay of perception, action and ideas of self. Alternative explanations suggest a more general and unconstrained affective embodiment beyond spatial representation (Van Dantzig, Zeelenberg & Pecher, 2009), and detectable in language tasks. Dudschig, de la Vega and Kaup (2015) demonstrate valence-space interactions, but only when valenced language contains an embodied posture. Specifically, performing up/down actions responds to affective words that are strongly experienced in the body, such as '*proud*'. The potential overlap with spatial mappings has important implications in light of Lakoff and Johnson's observations about spatial and embodied metaphors (1980, 2003). Indeed, Citron and Goldberg (2014) note that metaphorical language is perceived as more emotive and simultaneously more grounded in physical experience. As metaphor is based on associative links between multiple concepts, this provides evidence for emotion interacting with experience.

On a neural level, evidence shows that emotion is processed by brain areas that are involved in other thought processes (Lindquist, Wager, Kober, Bliss-Moreau & Barrett, 2012), and not unique locations, supporting the assumption of an overlap between cognitive, affective and other functions. Emotion is processed within a distributed network which incorporates internal and external sources of physical awareness, such as autonomic and hormonal activation, and sensory areas of the brain, respectively (Barrett, 2009; Barrett & Bliss-Moreau, 2009). Panksepp (2004) suggests evolutionary mechanisms for this process, whereby primitive brain systems shared across mammalian species, for example the nervous system, are utilised by affective experience. This evolutionary perspective places emphasis on subcortical brain areas and the limbic system (Panksepp, 2005) and their role in coordinating sensory-driven and instinctual forms of affect (Panksepp, 2000).

Thus, the same networks that monitor internal homeostasis and physical awareness of the environment are also utilised by emotion, further demonstrating how an overlap between affective states and their corresponding physical characteristics can occur on a neural level. Harrison, Gray, Gianaros and Critchley (2010) demonstrate that emotion experience is directly associated with neural activation corresponding to specific bodily organs and processed as part of the central and peripheral nervous system. The paper argues that access to physiological feedback during affect provides evidence for embodiment, where body monitoring and internal feedback are recruited as part of processing emotion content.

Neurobiological perspectives also suggest that emotion is linked to language and memory, among other processes defined as ‘cognition’ (Duncan & Barrett, 2007), whereby affective connotations are a key part of language use and comprehension, and influence which words are retrieved from memory. Some affective connotations are accessed during lexical and semantic processing. Wurm, Vakoch, Strasser, Calin-Jageman and Ross (2001) asked participants to listen to spoken sentences and recognise words from non-words. Crucially, the tone of voice of the sentence could be congruent with the affective content of the key words, i.e., ‘happy’ voice with positive word, or incongruent. The study found that performance on the lexical decision task was faster when the emotional connotations of the spoken voice and the key word matched. Nygaard and Queen (2008) support this: when participants were asked to listen to spoken words and repeat them, naming latencies were faster when the emotional content of the key word matched the tone of voice with which the words were originally presented. This suggests that affective meaning is activated even when the task does not explicitly ask for awareness of the emotional content, and the semantic content of the word and the perceptual or sensory input, i.e., tone of voice, interact. Thus, emotion is not only cognitive in nature, and potentially linked to mental representations of embodied and perceptual input, but also associated with language and meaning. Vigliocco et al. (2009) describe emotion as one of the key sources of situated feedback, and in particular utilised to help represent abstract concepts.

However, evidence from experimental manipulations is necessary to fully demonstrate the interplay between emotion and embodiment. Posture manipulation can affect neurological activity when perceiving emotional stimuli (Benvenuti, Bianchin & Angrilli, 2013). Duclos, Stern, Sexter, Schneider and Laird (1989) also observe that manipulations of the face and body elicit emotion experience. Felt emotion is associated with corresponding behaviour and with physiological feedback (Mauss, Levenson, McCarter, Wilhelm & Gross, 2005), which is evident in observation of emotion. Sharif, Taylor, Atkinson, Langenecker and Zubieta (2013) confirm that performing, observing and imagining emotive actions all increase perceived emotion. This is consistent with the assumptions of situated cognition, as mental imagery and comprehension of actions activate the same neural representation and have similar effects as action execution, supporting the claim that conceptual understanding and experience share neural substrates. Specifically, this includes the hypothalamus, somatosensory and fronto-cortical areas (Viinikainen, Glerean, Jääskeläinen, Kettunen, Sams, & Nummenmaa, 2012), which are activated by positive and negative affect, but not neutral. Pessoa (2017) discusses a functional model of emotion and argues that many brain structures are recruited for emotion processing, including integrated systems that link to the hypothalamus, brain stem and medulla, and thus provide access to information from the autonomic nervous system, physiological and musculoskeletal feedback. Pessoa (2017) claims that, while specific areas are associated with specific actions, such as the ventral striatum with reward and aversion, it is the neural integration between multiple areas and especially links to the hypothalamus that underpin the way emotion interacts with cognition, perception and action.

There is also evidence that the association between emotion and body feedback persists even without conscious experience of emotion. This can be investigated through implicit manipulation of the face or body, eliciting the same physical feedback without awareness of the emotive content. A well-known and contentious study by Strack, Martin and Stepper (1988) show that manipulations of the face influence ratings of 'funniness'. When the face is manipulated to resemble smiling, cartoons are rated as funnier compared to a 'frowning' condition. While the study is widely contested in the literature and has not been replicated successfully (Wagenmakers et al., 2016), the implications beyond perceptions of humour are more promising, for example effects on comprehension in language. Glenberg, Havas, Becker and Rinck (2005) employ the same face conditions and report significant effects on valence recognition of sentences. When participants were asked to read affective sentences and identify them as either positive or negative, performance was better when 'happy' sentences were read during the 'smiling' facial manipulation and 'sad' sentences – during the 'frowning'. When the facial condition was inconsistent with the stimulus valence, performance was inhibited. Havas, Glenberg and Rinck (2007) confirm this, showing that 'smiling' facilitates recognition of positive language and inhibits negative. Further, Soussignan (2002) demonstrate that manipulation that successfully elicits a Duchenne smile – the so-called 'true smile' – results in increased physiological activation, suggesting that embodied feedback is more effective the more closely it reflects the natural patterns of emotion expression.

Despite growing evidence for the embodiment of affective facial feedback, the full body has received less focus overall (see Chapter III for more detail). Most research investigating posture and motion observes physical responses to reading or producing affective language, such as writing about autobiographical experience (Kang & Gross, 2015). Casasanto and Dijkstra (2010) asked participants to remember positive and negative autobiographical events while simultaneously performing a physical task, i.e., moving marbles on a board upwards or downwards. The study established that direction of movement interacted with the valence of the story, whereby more positive memories were recovered during upward movement, and more negative – during downward. This suggests an overlap between spatial and valence mappings, where 'up' is associated with positive affect and 'down', with negative, and these mappings are elicited by corresponding movements of the hands.

However, the role of the body goes beyond spatial codes. Dijkstra, Kaschak and Zwaan (2007) asked participants to recall specific autobiographical events, e.g., going to the dentist or playing sports. During recall, participants were placed in a position either consistent with the memory, i.e., lying down while describing being in a dentist's chair, or inconsistent, i.e., lying down while describing sports. The position influenced recall, with memory improved in the congruent condition and poorer for incongruent trials. Riskind (1983) extended this to posture, showing that memory for 'happy' personal events is improved during smiling and expansive body posture, while negative memory is improved by frowning and slumping conditions. Thus, bodily movements and states, including posture, interact with affective memory and show distinct associations for positive versus negative emotion.

Motion-tracking research has consistently reported highly specific patterns of body activation for different emotion categories, where positive affect is characterised by open, expansive posture and fast motion, and negative emotions such as sadness or fear are instead constricted, with lowered head and slumped shoulders (Crane & Gross, 2013; Gross, Crane & Fredrickson, 2010). Moreover, the patterns for positive and negative emotion do not overlap, implying that affective states have stable and distinct associations with the body. This provides evidence that musculoskeletal feedback has strong links to emotion experience and conceptualisation, and is thus suitable for exploring the overlap between physical semantics of posture, i.e., affective associations, and verbal semantics of language, i.e., valence. Further exploration is necessary to establish whether the experimental paradigms successfully used for face manipulation (Glenberg et al., 2005) can also be effectively applied to the body.

1.2.3. Emotion and language – some points of caution

To conclude, the literature discussed so far provides a clear indication for embodiment of affective feedback, and suggests that language is likely to be receptive to embodied priming. Continuing to explore affective language and its links to the body offers a valuable avenue for research. However, further research on the topic needs to consider additional factors that may represent a confounding influence. In particular, studies aiming to use linguistic stimuli such as words or sentences should ideally account for affective properties beyond valence, i.e., positive or negative emotion. These key confounds include arousal and dominance, where arousal refers to the strength of the emotional activation and excitation, and ‘dominance’ represents the level of agency and control, i.e., in control of one’s own actions and the situation versus feeling controlled by external circumstances.

Smith and Ellsworth (1985) discuss six dimensions for conceptualising emotional experiences, including pleasantness, attention, i.e., willingness to engage with the emotion or not, effort, responsibility, i.e., self or other, certainty and situational control. They also observe different patterns for affective states, beyond valence, where attention and control distinguish many positive and negative states from each other. Citron, Weekes and Ferstl (2013) also demonstrate that valence and arousal interact on a neural level, with distinct patterns for positive and negative versus neutral affect. Even when conscious evaluation of emotive content is not required by the task, valence and arousal elicit joint activation within brain areas associated with interoceptive feedback and emotion (Citron, Gray, Critchley, Weekes & Ferstl, 2014), implying that the interaction between valence and arousal, and not affective category alone, results in automatic activation and is sensitive to embodiment.

This is at least partly consistent with the approach/avoidance account of emotion, and highlights the need for considering more than just valence when investigating the cognitive associations that accompany affect. ‘Dominance’ ratings offered by the ANEW (Bradley & Lang, 1999), EMOTE (Grühn, 2016) and Warriner, Kuperman and Brysbaert (2013) databases, provide a readily available method to account for these properties when planning further research.

1.4. Conclusions – what do we know so far and what needs to be done?

Evidence for the embodiment of cognitive constructs, including emotion, has been accumulating in recent decades. While research reports spatial mappings of positive and negative emotion and thus extended associations between sensory experience and verbal semantics, the role of internal body feedback is less explored. Experimental conditions affecting language through embodied manipulation are mostly centred on the face and lack experimental control over language stimuli, while the body as a whole is observed through motion tracking, and not experimentally induced manipulations. Moreover, experienced emotion goes beyond valence, and further research needs to account for such confounds before embodiment is fully understood.

This thesis argues that too much focus has been given to contrasting positive and negative language without a suitable control condition, and without acknowledgement that neutral expressions are a natural and frequent part of day-to-day language. It is necessary to address methodological issues with past research, where no control condition, i.e., neutral language, and stimuli with widely varying length are employed (Glenberg et al., 2005; Havas et al., 2007; Nummenmaa, Glerean, Hari, & Hietanen, 2014). Neutral items present a suitable control condition not only due to absence of affective content, but also since they would be 'exempt' from the bodily associations that strongly positive and negative emotions display, and thus not receptive to embodiment. Previous research has identified that positive, negative and neutral are the three categories most strongly recognised from sentences (Wu, Chuang & Lin, 2006), and this is sensitive to semantic labels, i.e., key valenced words used to indicate the overall valence of each sentence. In addition, it is suggested that detecting embodied effects in language requires strictly controlled stimuli, and is best explored through sensitive measures such as reaction time (Bergen, 2007). This poses issues for interpreting findings where stimuli with variable length are employed, as baseline differences in reading speed would confound any measurement.

The current doctoral project aims to extend previous findings to the full body, specifically 'open' and 'slumped' posture as reflective of positive and negative states, respectively. While previous research has often focused on posture as a result of emotion re-experience or memory, and not vice versa, the proposed embodied effects include dynamic, frequently updated perceptual and interoceptive information (Barsalou, 1999), and thus should be receptive to experimentally induced short-term manipulation, and not only prior experience. Further, the project aims to develop language items consistent with positive and negative valence, but more highly controlled than previously used materials, and also inclusive of neutral language. Third, this will be explored through three forms of performance. Embodied effects have been observed in valence recognition of sentences (Glenberg et al., 2005) and memory of affective words (Michalak et al., 2015). Embodied mental representations are also discussed as a function of narratives and storytelling (Zwaan, 1999). Therefore, the current project will explore the previously observed recognition of valence and memory of words in sentences, and extend this to comprehension of full text.

In summary, embodied and situated models of cognition state that semantic representations of the body, i.e., intrinsic awareness of internal states, overlap with verbal semantic representations, including affective content in language. Thus, approach/withdrawal or open/closed bodily states may prime recognition and memory for positive and negative emotion, respectively. The current thesis explores this cross-modal semantic priming through three experimental paradigms.

2. Chapter II. Development and validation of materials: Pilot study

2.1. Background and development

A primary goal of the current study was to use language stimuli with greater experimental control compared to previous research, in particular of linguistic properties. This required the establishment of clear, consistent criteria that can guide stimulus creation and maintain the methodological and conceptual principles at the foundation of this project.

Namely, materials needed to be designed specifically to contain emotional content and group in overall general categories, governed by concrete linguistic constraints, and as balanced across properties as possible. The valence groups chosen for this project were positive, negative and neutral language. However, to ensure that any variability stems from valence, and not other factors, arousal, dominance and word length were also taken into account.

The first factor considered were purely linguistic properties outside of emotive content. This included readability, ease and speed of processing required for comprehension, semantic and syntactic clarity, sentence length. The baseline amount of time and effort necessary for reading, processing and understanding a sentence are important when examining these measures (reaction time and judgment accuracy) under different experimental factors. Specifically, any unplanned baseline differences in stimuli may introduce or mask the effects under investigation.

Previous research into language and emotion has used language developed or adapted to portray emotional content. A prominent example are the stimuli employed by Glenberg, Havas, Becker and Rinck (2005), and Havas, Glenberg and Rinck (2007). They consist of 96 English sentences, and are specifically grouped by positive or negative valence of affect. An example 'pleasant' sentence is '*The college president announces your name, and you proudly step onto the stage*', and an example 'unpleasant' sentence is '*The police car rapidly pulls up behind you, siren blaring*' (Glenberg et al., 2005, p. 122). However, other examples consider different text types, such as short vignettes describing an emotionally-charged scenario. Nummenmaa, Glerean, Hari, and Hietanen (2014) used such vignettes denoting multiple distinct emotional states, and not grouped by valence.

Nevertheless, these materials appear to include a great amount of linguistic variability. Sentences differ in length, with some items consisting of nine words, and others of thirteen.

The variability is wider with other textual forms, as vignettes may include one to several sentences. The materials also do not consider syllable and letter count, nor word frequency. These properties can affect how easily and quickly a sentence is understood. Although this type of variance may not preclude forming clear, accurate meaning and understanding of emotional content, in time-sensitive experimental conditions such differences add unnecessary risk of confounding any investigated effects on comprehension speed.

Thus, the current project aims to introduce a more restrictive guideline for item creation. An arbitrary limit of seven words per sentence was established. Although this is a comparatively short length, it still allows for the creation of double-verb sentences, while ensuring each item is quickly and easily processed. In order to minimise potential variability, this criterion on length was set strictly, regardless of word type, and including propositions, connecting words such as “near”, “around”, “above”, as well as functional verbs such as “be” and “do”.

The second set of measures concerned with linguistic balance and readability was syllable and letter length. These properties reflect how pronounceable a word may be, with increasing syllable count strongly relating to the overall length and thus complexity of a word. Criteria for these aspects were also established, and a described in more detail below.

Outside of readability, emotional content itself may present a more complex front than previously considered. Past research has used sentences to describe a brief scenario with emotional context and influence (Glenberg et al., 2005, Havas et al., 2007). While the overall sentence creates a clear affective message, the influence of individual words is not considered. Guidelines on how sentences were composed on word basis are not provided. This does not account for the individual emotional connotations of specific words, and how they may interact with the overall affective response. For example, positive words in a negative sentence, and vice versa, may implicitly interfere with comprehension of valence and impede the accuracy or speed of this processing.

Research has indeed demonstrated that individual words present clear and specific associations with emotional states. Studies have compiled word-sets of thousands of lemmas, rated for emotional properties, among which valence. This has resulted in databases of affective language, for example the Affective Norms for English Words (ANEW) project developed by Bradley and Lang (1999), and the recent English Word Database of Emotional Terms (EMOTE) introduced by Grühn (2016). Perhaps the largest such project was established by Warriner, Kuperman, and Brysbaert (2013), and considered 13,000 English words. Research has shown that such key valenced words serve as a functional part of valence recognition from sentences (Wu, Chuang & Lin, 2006), where the sentence can be represented as a sequence of semantic labels, i.e., words or phrases that convey important semantic information. Each of these words is activated during emotion processing or recognition, but they are also related to the sentence as a whole to grasp the full meaning.

This has important implications. First, individual words do present affective associations outside of immediate context. Second, emotional meaning in language is built by other factors, outside of valence itself, for example arousal and dominance. Arousal represents the level of psychophysiological activation induced by the emotion, while dominance refers to how in control the individual feels versus feeling controlled by external influences. As far as literature review has been able to establish, measures of arousal and dominance, or even valence itself on a word basis, were not taken into account when developing previously used linguistic materials. While such stimuli target and refer to emotion, they may not be sensitive to the different factors interacting to create emotional experience, or the psychophysiological properties supporting it.

The current project aimed to consider sentences not only as a whole, but also as a cohesive collection of individual words. Thus, item creation began from word level, where separate lemmas were selected, their affective and linguistic measures collected, and only then connected in sentences.

The study collected this information indirectly, by consulting the previously mentioned databases of participant-rated affective words. Several databases were reviewed, including the ANEW (Bradley & Lang, 1999), and EMOTE (Grühn, 2016). However, the Warriner et al. (2013) was finally selected for several reasons. It provided the widest range of words, up to 13,000, which allowed more ecological validity of language and greater variability of word choice, while also maintaining statistical control. It also included an indirect measure of word frequency; namely, all words with frequency rates under 20, or missing values, were excluded from the final dataset. As either frequency information or data-richness were limited in other databases, with missing data points, the Warriner et al. (2013) was considered most practical and sufficient in provided the desired control measures.

Using the entire database, statistically determined categories were created. Letter and syllable length were calculated in Excel via formulas. Means and standard deviations (SD) for all target measures – valence, arousal, dominance, letters and syllables, were calculated. Then, upper and lower cut-offs at 1.5 SDs above and below the mean, respectively, were established. All measures were separated into high, medium and low groups. Thus, although variables maintained a scale-point value (1-9 for affective properties, continuous for letters and syllables), they were also largely grouped based on variability from the average. This resulted in the negative, neutral and positive valence categories that guided the development.

Thus, word-based affective properties were taken into account when developing stimuli and ascribing them preliminary affective categories. The most important factor was word valence, ranging from highly negative to highly positive. However, arousal and dominance were examined and counterbalanced as much as possible.

Although perfect counterbalancing would have required a complete matrix of every affective property (valence, arousal, dominance) by the other, and by every level, after consultation of the word databases that was considered impractical. First, items low in arousal, while high or low in valence, were rare in comparison. Similarly, items high in dominance were more likely to be positive than neutral, and especially negative. After application of statistical controls, it was especially difficult to select items where valence, arousal and dominance all interact. For example, there were no words with negative valence, low arousal and high dominance, when determining these labels statistically by deviation from the mean.

Second, it is possible that these partial interactions reflect inherent, ecological relationships between affective properties. Research has supported this assumption. Warriner et al. (2013) notes that positive valence and high dominance/control are correlated, as well as for negative valence and low control. The relationship between arousal and valence is especially well documented (Citron, Weekes, & Ferstl, 2014). Papers consistently report a U-shaped curve, where words positive and negative in valence are high in arousal, and words neutral in valence are low in arousal (Bradley & Lang, 1999; Redondo, Fraga, Padrón, & Comesaña, 2007).

Due to these considerations, full counterbalancing was not implemented. Instead, several principles were put in place. Items were controlled for arousal and dominance across all valence conditions. Only items with intermediate arousal and dominance were used. Words with high or low arousal and dominance were not included. Thus, 'neutral' items had intermediate valence, arousal and dominance, while positive items were high in valence, but intermediate in arousal and dominance. No negative words with high dominance, nor positive words with low dominance, were used. Linguistic properties were also considered, where words with letter and syllable length below or above cut-off were excluded. This resulted in length of up to 4 syllables, and up to 10 letters per individual word.

After these selections, sentences were constructed from individual words. Measures of valence, letter and syllable length were collected for each word and compiled. Sentences also consistent of words with no valence rating, as they were not included in the database. However, those words were either propositions, functional verbs ("do", "be") or connecting words ("near", "when"). Valence consistency was the most important principle of sentence development. Neutral sentences included words with neutral valence only. Negative sentences consisted of negative and neutral words only, with no positive, while the opposite was true for positive items.

Finally, average values of valence, overall syllable and letter length, were calculated for each sentence. Despite the presence of words with congruent valence, sentences were not considered positive or negative until they met the same criteria established for words. Namely, the average valence of the sentence, based on the valence of each word included, needed to be below/above the cut-offs. Sentences with valence not meeting those criteria, or with longer syllable and letter length, were adapted or excluded.

This process resulted in a set of 136 sentences, measured and balanced for valence and approximate readability. The stimuli employed statistically controlled, restrictive definitions of affective categorisation, and excluded confounding relationships of valence, arousal and dominance as much as possible. Although there was some variability in syllable and letter length, it was not considered an issue at this stage, as sentence length was consistently limited to seven words with strict limitations of length. Additionally, while the study aimed to introduce maximum control of confounds and clear, statistically-supported reasoning, it was not intended to avoid naturally occurring, ecological variability, as long as it was not expected to have clear, direct confounding effects.

Therefore, the current process of stimulus development succeeded in developing a set of affective language sentences, demonstrating clear valence distinction and balanced according to statistically verified criteria. Nevertheless, these materials need to be validated in real-word conditions, and to receive participant ratings that demonstrate the intended level of affective distinction. The following experiment aimed to: collect participant categorisation of valence; examine the consistency and reliability of these ratings; collect processing times as a measure of readability and comprehension; investigate any potential group differences that could confound valence effects. Additionally, the study will aim to evaluate and adapt materials on the basis of these measures, and continue development toward the creation of a consistent, statistically controlled and rated set of emotive language stimuli.

2.2.Method

2.2.1. Design

A pilot rating experiment was employed. The goal was to collect data categorising 136 English sentences based on valence, namely negative, neutral or positive. Although items were created specifically categorised for valence, the experiment did not compare responses to these initial measures, instead taking the participant-given judgment as baseline affective categories.

The study aimed to examine two measures: ease of comprehension and recognition, indicated by reaction time of responses; and valence consistency, as measured in between-participant agreement on judgments (in percentage).

These data will show whether the current language materials are able to induce consistently recognised emotive meanings, as well as be processed with sufficient and consistent speed. Additionally, this validation would indicate potential differences in linguistic (reaction time of reading and comprehension) and affective (valence agreement) properties between the emotive categories.

2.2.2. Participants

The experiment used an opportunity sample recruited on voluntary principle. Recruitment was conducted on the grounds of Northumbria University, through personal contacts, university email lists and a brief advertisement distributed on the premises. Volunteers were required to have native or near-native English language proficiency, and no severe language disabilities that would prevent them from successful comprehension of the linguistic materials. The sample included 16 participants, 11 females and 5 males. Twelve participants were native English speakers, and four had bilingual proficiency. All participants had a university degree or above, with several in current postgraduate study (Master's or PhD), and several with completed doctoral degrees. All participants studied or worked in psychology.

2.2.3. Materials and apparatus

The study used a brief demographic questionnaire, asking participants about their age, gender, native language, level of proficiency in English, and history of learning disabilities. The experiment used to collect valence ratings utilised a computerised program. This was run on a laptop device with 15.6-inch LCD display. A portable computer was selected purposefully in order to allow greater manoeuvrability of the presentation. As the current experiment is a pilot study, informing future projects, this presentation style was chosen in congruence with technical demands of the intended follow-up study.

The experiment presented the language materials under validation, specifically 136 English sentences. These stimuli were designed to portray different emotive categories, namely negative, positive and neutral affect. The list included 42 negative, 42 positive and 52 neutral sentences. All items contained seven words, including propositions and connecting words, with an average of 11 syllables and letter length of 32 per sentence.

The materials were designed to represent relatively extreme points of the emotional spectrum – intense, highly positive or negative affect, and an unequivocally neutral medium. Example items of each affective category are presented below.

Negative: “His misfortune ended in a crippling debt.”

Neutral: “There was a train passing through town.”

Positive: “She kissed her husband with warm affection.”

Although items were categorised on valence, as stated, these labels were established as preliminary guidelines during development. The purpose of the project was to obtain category grouping based on the participants’ responses. The sentences used from this point onwards, i.e., in the next three experiments, were selected only from items whose category is confirmed by participants. Items whose initial valence category is not consistently recognised and confirmed by the participants were identified for removal.

2.2.4. Procedure

Participants were recruited on a voluntary basis. They were presented with an information sheet detailing the purpose of the study and asked to provide written consent to participating. They were then asked to complete a short demographic questionnaire and then proceeded to the experiment. The study used a computerised paradigm presented via the open-source software OpenSesame. Participants were presented with one of two version of the experiment. This was decided in order to counterbalance response type.

The presence of three answer options – negative, neutral or positive affect – necessitated three distinct responses via the keyboard. Although these could be situated in near proximity, e.g., arrow keys, it was felt that this could confuse responses when fast reaction time is also required. Thus, the “z” and “m” key, on the left and right end of the keyboard, and “space” key in the middle were chosen. While these conveniently represent the categorisation of affective stimuli – polar ends of the spectrum and midpoint – the study also did not want to establish stable associations between direction and valence. Further, as inherent spatial-emotion associations have been suggested in research, but not decidedly agreed on, the current project aimed to counterbalance such potential influences on response as much as possible.

Thus, the presentation of language stimuli was separated in two halves. In either section, the "z" key represented either negative or positive emotion, with the opposite for "m". Namely, if in Part 1 "z" meant "positive" and "m" – "negative", this was reversed for Part 2. The "space" key continued to represent neutral emotion throughout. However, in order to ensure that this counterbalancing did not affect sentences differently, the two experimental versions were developed. Although they included the same sentence lists for each half, the order of response – whether "z" is negative or positive first – was reversed. This meant that each sentence was responded to in both ways, and any potential influences of spatial orientation would nullify each other.

Participants were randomly allocated to either version, with equal numbers. The program was also used to present written instructions to participants, although additional verbal explanation was provided alongside. The experiment reminded participants that they are asked to rate sentences as negative, neutral or positive in emotion in accordance with their own understanding. Participants were also asked to respond as quickly as possible when they were sure to have processed the sentence.

The experiment presented individual sentences centred on the screen. Text was written in "mono" font, font size of 26, no colour. Sentences were presented with no timeout, until a response was given. Items were separated by fixation dots at the centre of the screen, with duration of 750 ms. Although the first and second half of the experiment always included the same sentence lists, items were fully randomised within each part.

The instructions to participants were fully written and repeated verbally before each experimental half. Additional reminders about the response keys were added in the form of small paper labels with + for "positive" and – for "negative". Participants were allowed to have a small break between the two experimental halves. After they had completed the experiment, they were thanked for they help and debriefed in verbal and written form, explaining more about the purpose of the study. This procedure lasted approximately 5-10 minutes. The study and its protocol were reviewed and received full ethical approval from the Ethics Committee of the Faculty of Health and Life Sciences, Northumbria University.

2.4. Results

2.4.1. Data processing

The collected reaction times (RT) and valence judgments were processed in Microsoft Excel. Judgment responses were converted from raw scores (keypress) to valence labels. Responses were reverse scored in accordance with the counterbalanced paradigm condition.

On valence, the amount of observations of each affective category was counted. This resulted in a score for each category of minimum 0 and maximum 16 – sixteen participants rating the sentence in the same valence. The score was consequently converted into percentage of the overall responses that agree on classifying each item as positive, negative, or neutral. Items with less than 80% agreement were excluded. This was selected as a relatively arbitrary criterion of high agreement, above chance and more than one standard deviation (SD) above the mean rating for the sample.

Average reaction times and standard deviations per participant and on individual item basis were calculated. Due to technical issues during the experiment, one participant experienced a blocked screen. This resulted in an RT of over 96,000 ms on one particular item. Given the mean RT for that participant and the entire cohort were below 3000 ms, this was identified as an experimental error and that specific data point was removed. No other participant data was removed.

Upper cut-offs were calculated for each participant and for the entire sample, at two standard deviations above the mean. Additionally, descriptives and cut-offs of RTs per individual sentence were calculated to aid the items analysis. Based on these measures, discussed below, three items had mean response times above the upper cut-off of 2262.52 ms, and were consequently removed from further analysis.

2.3.2. Items analysis

Overall, reaction times and valence judgments revealed good consistency of the language stimuli, in both readability and effective depiction of emotive content. Initial valence agreement ranged from 56% to 100% (percentage of the highest scoring, thus most recognised affective category). Nevertheless, the mean rating was 90% (SD = 8), presenting a good overall agreement base. After deletion of items under 80%, the mean was 92% (SD=5).

Prior to deletions, RTs had a sample mean of 1701.91 ms, with an SD of 826.52 ms. Importantly, average RTs on item level were also investigated in order to identify stimuli with potentially problematic differences in comprehension. Once cut-offs were established at two SDs above the mean, problematic items were removed.

Table 1. Mean (SD) reaction times (ms) of judgment per sentence item, averaged across participants; prior to and post deletions.

N=90	**Initial (N=136)**	**Post-deletion (N=121)**
Mean RT (ms)	**1702.08**	**1677.20**
SD	280.22	213.31

As Table 1 demonstrates, both prior to and after item restriction, standard deviations show small variability, which can be interpreted as indicative of good response consistency.

Nevertheless, deletion of items improved valence judgment agreement – the primary goal of the validation procedure. The resulting list consisted of 121 sentences – 41 negative, 46 neutral, and 34 positive, ranging from 81 to 100% on judgment consistency. This list was analysed further to investigate any differences between the three affective categories.

2.3.3. Analysis of valence categories

After establishing baseline item consistency, it was important to investigate valence groups separately, and in comparison with one another. This was conducted to ensure that group differences between items were due to valence itself, and not other linguistic or affective properties.

Descriptive statistics were run to identify the average reaction times and agreement on valence judgments for the new list of 121 positive, negative and neutral sentences.

Table 2. Means (SD) of average judgment agreement (%) and reaction time (ms) for sentences based on valence category.

N=90	**Negative (N=41)**	**Neutral (N=46)**	**Positive (N=34)**
Agreement (%)	**93.20** (05.50)	**91.98** (05.22)	**89.89** (05.96)
RT (ms)	**1629.15** (190.98)	**1698.85** (219.30)	**1705.87** (226.50)

Table 2 reveals there are small differences in valence agreement depending on affective category, with the highest percentage for negative and lowest for positive items. These findings were followed up with Analyses of Variance, to determine whether differences had statistical significance.

A one-way ANOVA was run to compare reaction times according to valence category. It revealed no significant main effects, $F(2,118)=1.60$, $p=.206$, showing that response speed was not influenced by type of emotion portrayed.

A separate one-way ANOVA examined differences in participant agreement on valence between the three affective categories. The analysis showed a significant main effect of valence category on agreement, $F(2,118)=3.40$, $p=.037$. Tukey's post-hoc comparisons revealed that the only significant difference was between positive and negative items, $t(119)=.02$, $p=.029$, with negative sentences (M=93.20) having higher agreement rates than positive (M=89.89).

These results suggest that although comprehension and readability are not influenced by type of sentence, valence categories have statistically significant differences in terms of consistent recognition. In overall, both response speed and recognition demonstrate consistent rates. Nevertheless, comprehension of emotive meaning appears to be dependent on distinct ends of the affective spectrum, with positive emotion identified least consistently and notably less than negative.

2.3.4. Final adaptations and implications

The language materials were validated as evocative of emotional content and valence categorisation, as well as easy and fast processing across items. However, results revealed that different affective categories, namely positive and negative, are recognised with different ease and rate of agreement. While this does not disrupt the stimuli's ability to effectively test emotion comprehension, the materials were intended for use in further experiments comparing external influences on positive and negative affect in comparison. The existing difference can pose a notable confound. In addition, some items were identified with less consistent agreement than the average rate.

Thus, before further use in experimental research, the materials underwent additional adaptations. Namely, more items were removed in order to make the set as consistent as possible. This included the items with lowest agreement score (81-83%), and items with the slowest responses. In order to counterbalance purely linguistic properties as well, sentences with the lowest and highest syllable and letter lengths were also excluded.

This resulted in a final list of 90 sentences, 30 per valence group. The average agreement rates, reaction times, as well as syllable and letter length, are presented below.

Table 3. Final set of sentence stimuli – mean (SD) valence rating, reaction times, syllable and letter length per valence category.

N=90	Negative	Neutral	Positive
Valence rating (%)	**94.38** (4.45)	**93.13** (4.14)	**91.44** (5.36)
RT (ms)	**1621.98** (202.09)	**1638.77** (163.27)	**1681.18** (229.80)
Syllable length	**11.50** (1.17)	**10.57** (1.38)	**11.23** (1.19)
Letter length	**33.37** (3.05)	**31.07** (2.33)	**32.97** (3.40)

Table 3 illustrates the final stimulus set, with equalised number of items per affective category and closer balancing on linguistic properties. Removing less reliable items did help improve the consistency of valence judgment, where all categories showed an average rating above 90%. An ANOVA was conducted to test the resulting set for group differences. The analysis confirmed differences in accuracy base on valence, $F(2, 87)= 4.49$, $p=.014$. Tukey's post-hoc comparisons indicated the only positive and negative sentences differed significantly from each other, $t(88)= .04$, $p=.010$. No significant group differences were found for reaction time, $F(2, 87)= .696$, $p=.501$.

Overall, reducing the sentence lists did help address other potential issues, increasing accuracy across all three categories, removing items with problematic recognition rate around 80% and further reducing variability in mean RT. However, the differences between accuracy on positive and negative items persisted. The implications are discussed next.

2.4. Implications for this project

The current validation makes headway toward establishing statistically controlled, yet ecologically appropriate materials for valence recognition from sentences. However, the confound between judgment agreement and sentence type still bears importance and should be strongly considered when utilising or adapting the current stimulus set. First, it may be of benefit to explore what factors could be influencing this relationship and driving the distinction between positive and negative affect. Second, further examination of the stimuli should be considered in order to improve their validity. This may include testing with a larger participant sample, but also adaptation and development of new items. In particular, positive items may need redevelopment to highlight more extreme and distinctly recognisable positive emotions.

Third, these results should be taken into consideration when planning the experimental paradigm, hypotheses and analysis of further studies. More specifically, this validation experiment was designed to pilot-test a study on the embodiment of emotion, and physical influences that induce selective effects on comprehension of different valence. However, an small, but notable inherent difference in processing positive and negative sentences poses a prior confound – whether methodological or conceptual.

Thus, research investigating responses to emotive categories should not compare these directly, as this may detect false effects, or mask existent ones. Instead, it may be beneficial to compare effects of other experimental factors within each valence category separately. This would allow investigating phenomena in isolation from any potential inherent differences between processing positive and negative emotion. Therefore, the next experiments in the project will have separate hypothesis and will conduct separate testing for each emotion category.

3. Chapter III. Study 1: The role of bodily feedback in explicit recognition of emotion in language

3.1. Overview

The chapter reviews the first study of the doctoral programme. First, literature linking two separate strands of research is discussed: background on facial manipulations and emotion recognition in language, and studies demonstrating correlates of emotion in body movement and posture. The Introduction then justifies the use neutral language as a control condition, and of open and slumped body posture as manipulations corresponding to positive and negative emotion, respectively.

Next, the study's methodology is outlined, including experimental design, participant sample, materials and procedure. Additionally, information about preregistration and methodological rigour are covered.

Third, results are reported in two main groups of analysis. The main, preregistered analyses, will report comparisons on two measures – accuracy and reaction times – between valence judgments made under the open and slumped conditions. These analyses are performed separately for negative, neutral and positive language. Results indicate that reaction time, but not accuracy, shows differences between open and slumped posture, and only on positive language items. Then, exploratory analyses which were not specified in the hypotheses or preregistration are reported. This will include: a mixed analysis of posture and valence taken simultaneously and demonstrating significant differences in valence regardless of posture; a mixed analysis with participants' usual posture as an additional factor; an analysis with order of conditions as a third factor.

These results offer partial support for the study's hypotheses. Namely, embodiment effects are observed on valenced items only, and not neutral, but with opposite direction than expected. This reflects contradictions between the current study on body posture and affective language and previous findings on facial manipulations. Results are interpreted in the context of research on the peculiarities of positive valence, explaining why positive language in particular may be more vulnerable to manipulation and thus more receptive to embodiment. Implications for general field and the next studies in the programme are discussed.

3.2. Introduction

3.2.1. Theoretical background

The current project is based on the premises of embodied cognition and the idea the abstract mental states are grounded in physical experience. The notion that the mind and body are not separate has been suggested as early as James (1980). More recent accounts have specified mechanisms through which body-mind associations are built. Barsalou (2008) suggests that perception and action offer experience, which then helps build abstract understanding. As such, conceptual knowledge uses information from the body, and thus can be influenced by it. Although the extent of this role is uncertain, there is evidence demonstrating interaction between physical and abstract systems.

One such system is language. Research shows that performing hand actions can interfere with processing language that implies action (Taylor & Zwaan, 2009). These patterns were identified in observation, execution and mental imagery of actions (Zwaan & Taylor, 2006), suggesting that multiple perceptual and motor systems help process motor-related language. Thus, the first observation from literature is that sensorimotor experience is involved in comprehension of abstract concepts, and that these effects are observable in language that describes relevant actions and states.

Furthermore, conceptual representations also interact with other domains, such as emotion. Emotion has been argued to affect human existence from areas like mood, subjective experience, social behaviour and mental health, to fundamental cognitive and neurobiological processes (Dolan, 2002). Reviewing evidence from physiology and neuroanatomy, Dolan summarises that emotion can influence: perceptual and attentional processing; memory and learning; decision making; brain anatomy, such as connectivity between emotion- and cognition-related areas, and neural plasticity. This suggests that emotion has not only widespread and automatic effects on cognition, but also an influence on how information is encoded and facilitated in the plastic, developing brain. This leads to the second theoretical premise of the study, namely that cognitive processes are responsive to emotion, and this relationship is strongly ingrained in the related neuroanatomical substrates.

The third line of enquiry aims to combine the above points. Specifically, both the embodied effects on language and the affective influences on cognition appear to stem from shared cortical recruitment and consistent, repeated associations between simultaneous activation in multiple modalities (Barsalou, 2008; Dolan, 2002). Psychologists argue that emotion happen not in encapsulated isolation inside the mind, but as relevant consequence or, indeed, preparation for physical experience. Fredrickson (1998) suggests an evolutionary role for emotion in preparing specific actions necessary for survival. For example, positive and negative emotion may prompt mechanisms for approach or avoidance, respectively, which in turn prime the organism for attack or escape. Similarly, James (1890) claims that emotion experience is grounded in unique, specific physiological states which it cannot be separated from.

This leads to the theory of embodied emotion. Prinz (2005) suggests that the experience of emotion is consistently accompanied by physical processes, such as physiological arousal, emotion-relevant action and even states of the body monitored by perceptual and motor systems. Thus, just as in classical embodiment of action and motion (Taylor & Zwaan, 2009), direct feedback from muscle activation and physiological reactivity supports the conceptual processing of emotion. This may include awareness of own feelings, but also more abstract functions such as comprehension.

Therefore, the final theoretical principle behind the current project suggests that emotion is embodied through information from the body, and this would affect its cognitive processing. If, indeed, embodiment of emotion follows the mechanisms outlined by Barsalou (2008), it is possible to expect that priming effects based on congruent bodily feedback would be observable in language.

3.2.2. Evidence from data

In order to establish whether comprehension of emotive language can be embodied, it is necessary to demonstrate: emotion-related facilitation or inhibition based on body manipulation, and; effects in abstract cognitive domains, such as language, and not only felt emotion.

Research has been conducted on manipulation of facial muscles associated with emotion. Glenberg, Havas, Becker and Rinck (2005) employed a task asking participants to hold a pen between their teeth or lips. Each condition taxed facial muscles differently, resembling positions that either resemble smiling or, conversely, preclude it. This task was undertaken while participants made valence judgments on a list of positive and negative sentences. When asked to recognise the emotion of sentences, participants performed better on positive items under the 'smiling' condition, and more poorly at negative. Precluding smiling elicited the opposite effects, suggesting that smiling can be considered a necessary source of feedback, without which recognition of the corresponding emotion category – positive effect, requires more difficult processing and thus shows poorer performance.

These influences were supported by Havas, Glenberg and Rinck (2007), namely facilitation based on the congruence between facial feedback and emotion in language, and inhibition when the necessary feedback is forcefully prevented. Niedenthal, Winkielman, Mondillon, and Vermeulen (2009) explored this further by measuring concurring electromyographic activity in the face. When participants were asked to read words, such as 'smile' or 'fight', and categorise them as affective or neutral, this elicited activation in the facial muscles dependent on emotion category, i.e., joy was associated with the zygomaticus and orbicularis oculi muscles, disgust – with the levator muscle, and anger with both. A following experiment utilised a manipulation holding a pen between the lips, which was expected to block facial expressions of joy and disgust. Results confirmed that the manipulation reduced accuracy of valence judgment for words related to joy and disgust, but no effect was found for anger-related and neutral words. This shows the bidirectional nature of embodied feedback: making judgments about affective language activates muscles used in emotion expression, and restricting these muscles slows down affective processes that are reliant on this relevant feedback. This pattern of results suggests that: physical feedback of emotion can interact with comprehension in much the same way as classic embodiment; this can be detected in language; the effect is automatic and independent of conscious experience of affect.

Although this can be interpreted as evidence for embodied emotion, it is only partial support. Less is known about the role of the full body. Motion, action and posture have been investigated, however only as consequence of emotion, and not manipulation. Research has been conducted on how felt emotion is experienced in the body (Nummenmaa, Glerean, Hari & Hietanen, 2014). Actions performed under affect also show distinct, contradictory patterns based on valence (Wallbott, 1998). Studies using motion tracking demonstrate that positive feelings – love, pride and joy, share features such as upright posture, lifted head, wide shoulder and elbow rotations and relaxed, fast movement. Conversely, negative affect, including sadness, shame, guilt, anxiety and fear, reveal a closed-off posture with slumped back and shoulders, reduced range and low speed (Crane & Gross, 2013; Gross, Crane & Fredrickson, 2010). However, this excluded anger, which manifested the same patterns as positive emotion, possibly reflecting the evolutionary approach systems suggested by Fredrickson (1998). Thus, for the purpose of this study 'negative emotion' will henceforth not refer to anger.

3.2.3. Rationale

In summary, the literature identifies several notable patterns. First, embodiment appears to be a consistent association between physical and cognitive states, serving as a shortcut to understanding by utilising shared cognitive and neural representation. As such, it can be observed when task-unrelated physical feedback interferes with abstract processing, and is often found through language.

Second, emotion has physical and neuroanatomical links with other cognitive processes, including comprehension. Thus, the interaction between these three factors – emotion, comprehension and physical feedback, is an excellent opportunity to explore embodiment beyond the classical hand-action paradigms, and investigate more complex motor systems. Although there is evidence for the embodiment of emotion, it includes experimental manipulations only on facial feedback. Research into the body observes typical patterns of coactivation between distinct emotions and body states, but does not explore the potential bidirectionality of the effect.

Thus, further research is necessary to investigate several gaps in the literature and: extend the facilitatory effects found in faces to the full body; extend the bodily correlates of negative and positive emotion to inducing, and not only reflecting affect; confirm the presence of full-body effects in an abstract cognitive task such as language comprehension.

3.2.4. Aims

The study aims to explore whether bodily feedback affects recognition of valence in language. Specifically, the experiment will employ a manipulation of posture in two conditions: open, with an upright spine position, lifted chin and relaxed, wide shoulders and elbows, and; slumped, with curved shoulders and spine, lowered chin and elbows held close to the body. The postures will be closely adapted from positions developed by Riskind (1984) and Riskind and Gotay (1982). However, the open posture will be slightly exaggerated and more expanded than the upright position used previously. The deception and manipulations will also be simplified, suggesting that the purpose of the study is investigating the comfort of the postures and its effect on cognition, without specifying the relevance of emotional information. Previous studies have used electrodes to measure facial muscle reactivity (Niedenthal et al., 2009), while others attached electrodes to the face (Riskind, 1984) or neck and wrist (Riskind & Gotay, 1982) as part of deception during the experiment. These conditions may introduce discomfort and an element of artificial environment. The current study aims to improve the ecological validity of the experiment by mimicking more naturalistic settings. Participants will be shown examples and instructions of the posture, but allowed to adapt the exact execution of the pose to avoid discomfort. The perceived comfort of the manipulations, as well as participants' own habitual posture, will be also be considered during analysis.

Nevertheless, the main outcome of the study will be performance on a language task. Valence recognition has successfully been used to demonstrate embodiment effects in faces (Glenberg et al., 2005; Havas et al., 2007), suggesting it as a suitable task for adaptation to a full-body paradigm. However, materials have been adapted to use stricter criteria of control. Importantly, the current study aims to include neutral language as a control condition, which is not expected to show influences of posture. Performance will be measured by accuracy and reaction time of judgments, and better scores would indicate facilitation of emotion comprehension.

Therefore, the study has three main hypotheses. It is expected that posture will interact with the valence of language, and will show selective differences between the open and slumped conditions. The direction of the effect is expected to follow previous findings on facial feedback, namely improvements based on congruence. Positive and negative valence are expected to show affective associations with open and closed posture, respectively, while neutral valence should not be influenced. Thus, the hypotheses are as follows:

H1: Recognition of negative sentences will be facilitated by the congruent feedback of slumped posture, and inhibited by open;

H2: The opposite effects will be true for positive language;

H3: Performance on neutral items will not be affected by posture, due to lack of congruent emotional feedback.

3.3. Method

3.3.1. Design

The study used a 2x3 repeated measures design to explore the effect of posture on valence recognition in language. The first factor was posture, specifically: open posture, intended as positive affective manipulation; slumped posture, corresponding with negative affect. Participants took part in both conditions in a counterbalanced order. The second factor was the emotion category of the language stimuli: negative, neutral and positive. The dependent variables concerned performance on a valence recognition task, namely accuracy and reaction time (RT) of judgments.

The study collected additional variables, which were not considered in the main hypotheses and the preregistered main analyses of the research. These were identified as potential confounds investigated in the secondary, exploratory analyses and included participants' self-reported usual posture, and the order of conditions.

3.3.2. Participants

The study employed a sample of volunteers recruited through opportunity sampling. Recruitment was conducted using university email, posts on social media, such as Facebook, advertisement posters placed on Northumbria University campus, and face-to-face on the University grounds during working hours. Undergraduate students were granted SONA points for their participation. No payment or course credits were offered in compensation. Exclusion criteria included: language level not approaching fluency; severe language disabilities; physical disabilities that would prevent participants from sitting in the two manipulation postures without discomfort.

The study identified language fluency and absence of language disabilities as criteria for inclusion. However, the final sample did include non-native English speakers, as well as individuals with self-reported dyslexia. Since participation was voluntary and no payment was offered, it was considered a priority to maximise recruitment and reduce any restrictions that could prevent certain groups of people from taking part. This was deemed acceptable as the study used strict exclusion criteria based on performance (see *3.4.1. Treatment of Data*). Thus, if performance were to be negatively affected by lower fluency, cut-offs would detect that and participants would be excluded at the data processing stage. While studies have suggested that non-native speakers have weaker emotional response to English words (Harris, 2004; Harris, Ayçíçeğí & Gleason, 2003), evidence shows that valence is rated as stronger in first language compared to second only for specific categories, i.e., taboo words (Garrido & Prada, 2021). The embodied effects explored in this project are intended to be independent from felt emotion, which could justify exploring them in fluent second language speakers as well as.

Volunteers with dyslexia were informed that the study would involve intensive use of language, and were advised to withdraw their participation at any stage if they experienced any discomfort. Dyslexia is known for slower processing speed on language tasks (Miller-Shaul, 2005), which could introduce unwanted variability on reaction time measures. However, the strict exclusion criteria for reaction time and accuracy used in this study can address this by removing data that ranges too far from the sample mean. The study also used a repeated measures design, which reduces the risk of participant variance between experimental conditions (Lamb, 2003). If participants did not indicate any issues, they were allowed to continue to the experiment, and their data were removed only if falling outside statistical cut-offs.

The initial study sample consisted of 60 volunteers. This sample was chosen as it corresponds to previous studies on affective embodiment in language (Glenberg, Havas, Becker & Rinck, 2005). An analysis with GPower (Faul, Erdfelder, Lang & Buchner, 2007) also identified that a sample of 62 participants would be appropriate for detecting a small-to-medium effect size in a repeated measures design, assuming statistical power of .80. Thus, this sample was selected as appropriate.

Six participants were excluded during data processing due to accuracy below the statistical cut-offs (see *3.4.1 Treatment of Data* for more detail). As agreed upon in the preregistration (see Appendix A for the preregistration forms), further recruitment was undertaken to supplement the sample to the intended number of 60. The full sample, including participants before exclusions, consisted of 66 volunteers, 43 female, 22 male, and one self-identified as 'other'. The mean age was 24.99 years (SD=7.79). The sample used in the analyses, following exclusions, included 60 participants, 38 female, 21 male and one 'other'. The mean age was 25.08 years (SD=8.05), with a minimum of 18 and maximum of 65 years.

3.3.3. Materials

The study employed language stimuli, namely a list of 90 sentences in English (see Appendix C). Stimuli consisted of three categories – negative, neutral and positive in emotional content, 30 per group. The materials were developed specifically for the experiment, and constructed using a database of individual words rated for valence (Warriner, Kuperman & Brysbaert, 2013). All stimuli were seven words long, and were pilot tested for reading speed and consistency of valence recognition. For more details, see *Chapter II. Material development and pilot testing*.

A computer-based experiment was used for the presentation of language stimuli and collection of judgment responses. The paradigm was presented using the open-source software OpenSesame. The experiment was performed on a standard laptop device running Windows 7. No other equipment or software and no connection to the internet were required.

The research also collected additional information through a paper-based self-report questionnaire. This included demographic variables, such as: age, handedness, gender, native language, English language fluency (low, functional, working, or full proficiency), education level (A levels to Doctoral degree), and asked whether participants had any language or physical disabilities. The questionnaire also enquired after variables related to posture, namely: participant usual posture (open, slumped or neutral/mixed); frequency of sitting in open and slumped posture, respectively (Likert scale from 1: Never to 7: Always), and; preferred posture in terms of comfort. A follow-up questionnaire, completed after the study, included questions verifying whether: the sentences were clear; either posture was more comfortable, and; participants expected the true nature of the experiment.

3.3.4. Procedure

The study and its protocol received full ethical approval from the Department of Psychology Ethics Committee in accordance with the Faculty of Health and Life Sciences Ethics Committee, Northumbria University.

Volunteers were met by the researcher and given an Information sheet (see electronic Appendices for all ethics documents) detailing the purpose of the study. This involved deception – participants were informed that the research investigated the comfort level of the two postures, rather than the expected emotional association. Following this, participants signed a written consent form and proceeded to complete the first page of the Demographic questionnaire. Then, participants were explained the experiment and the posture manipulations, and shown an instruction page demonstrating the postures in images and writing (Appendix B). Participants proceeded to take part in the computer experiment. It presented detailed instructions and a practice session designed to familiarise participants with the stimuli and responses.

The full experiment was separated into two halves with a short, self-paced break in the middle. During each half, participants sat in a different posture. Sentences were presented individually on the screen either until keypress or for a maximum of 3500ms. After this period, items would time out, proceed to the next screen, and the trial would be considered incomplete. All trials were separated by a central fixation dot presented for 750ms. Sentences were presented in randomised order. Responses were indicated via keypress.

Specifically, the response keys were Z, M and Space. However, due to associations found between left-right space and emotional valence (see *Chapter II. Material development and pilot testing*), it was deemed prudent to counterbalance response keys. Thus, two experimental lists were formed. In List 1, first half, participants would respond with Z for positive items and M for negative, while in the second half they would be reversed. In List 2, that order would also be reversed. The correct response for neutral items was always Space, across lists and halves. Due to these changes, there were two separate practice sessions before each half, allowing for familiarisation with the response type.

At the end of the experiment, participants were shown an estimation of their average accuracy and reaction time. Then, they proceeded to complete the second part of the Demographic questionnaire, namely questions on their usual posture, and the post-study verification questions. Following this, participants were thanked for their time and fully debrief, including explanation of the deception used.

3.4. Results

3.4.1. Treatment of data

Raw data scores were collected, including keyboard responses and corresponding reaction times (RTs) for each item. Data underwent initial processing, such as removing artefacts. Items where a response was not given within the required time were coded as 'incorrect' and resulted in RT values of 3500ms. These were removed from data. Reaction times for incorrect items were also removed.

Next, data underwent processing and exclusions following the preregistered criteria (see Appendix A). Accuracy criteria included 2.5 SDs below the sample mean; in the original sample of 60, this resulted in a mean of 92% and cut-off of 65%. A slight modification to the preregistered criterion was undertaken. Namely, some participants had overall accuracy above 65%, however accuracy on neutral sentences below that, including values as low as 20% or 0%. As responses for negative, neutral and positive items were looked at separately, it was considered that participants could be removed if their accuracy for any language category was under this criterion.

Additionally, cut-offs for RTs were preregistered and included. On the participant level, items 2.5 SDs above the participant mean were removed. On the sample level, participants whose mean RT was 2.5 SDs above the sample mean were excluded. However, exclusions on the sample level were determined by the original sample mean, SDs and cut-offs: the values before removals on the item level, exclusion of participants, and before the addition of six further participants to supplement the sample (see *3.3.2. Participants*). After these exclusions were performed, the final sample means were 95% for accuracy (SD=4%) and 1422.81ms for RT (SD=359.83ms).

A preliminary items analysis was run to identify any problematic items. The overall mean values corresponded to the sample means: accuracy at 95% (SD=3.8%), RT of 1449ms (SD=143.94ms). The lowest accuracy was 81%, while the maximum value was 100%. This suggested no problematic values that might require removal.

3.4.2. Analysis plan

The study investigated whether posture manipulation could influence valence recognition judgments of affective sentences. Analyses include accuracy and reaction time measures. As per preregistration, the research conducted main analyses for hypotheses testing, and additional exploratory analyses. First, main analyses will be reported – Analyses of Variance comparing open and slumped posture on accuracy and reaction time. These will be done for negative, neutral and positive valence separately. Second, exploratory testing will be include: 2x3 repeated measures analyses of posture, valence and their interaction; mixed analysis with usual posture as additional factor; mixed analysis with order. An analysis with usual posture was appropriate as participants' habitual posture, in particular extreme 'slumped' or straight posture, may affect how they respond to the experimental condition.

3.4.3. Main analyses: Accuracy

Descriptive statistics show average accuracy for negative, neutral and positive items (Table 4.).

Table 4. Mean (SD) accuracy (in %) for valence recognition judgments in open and slumped posture.

N=60	Negative	Neutral	Positive
Open posture	97.11 (5.67)	94.33 (8.58)	92.67 (9.32)
Slumped posture	96.67 (5.58)	94.11 (8.69)	95.11 (7.04)

Inferential statistics were run using within-subjects Analyses of Variance (ANOVA) using the software package IBM SPSS Statistics 22. An ANOVA was used as it has been found robust, producing acceptable Type I error rates despite non-normal distribution, unequal sample size or unequal distribution within experimental groups (Blanca Mena, Alarcón Postigo, Arnau Gras, Bono Cabré & Bendayan, 2017). Departures from normality are known to reduce estimates effect size and result in misleading estimates of power (Tukey, 1960). T tests may result in unfavourable Type I error rate in populations with unequal variances (Wilcox, 1995), while ANOVA can be robust in terms of power when participant samples are equal (Coombs, Algina & Oltman, 1996) and thus appropriate for this study.

Three separate analyses were performed to test negative, neutral and positive sentences. In order to avoid increased rates of Type I error due to multiplicity of testing, the study used Bonferroni corrections. Thus, the *p* value required to reach significance was divided by the number of analyses. However, the analyses were not corrected for testing both accuracy and reaction times, as they were considered different, and sometimes contradictory, measures of performance. As a result, the significance thresholds for all main analyses was set at $p = .017$.

3.4.3.a. Negative valence – accuracy

A within-subjects ANOVA was performed to investigate the effects of posture on recognition of negative sentences. The analysis revealed no significant differences between the open and slumped postures, $F(1, 59) = .33$, $p = .568$. Partial Eta squared revealed that the manipulation accounted for less than 1% of the variance between scores, $\eta_p^2 = .006$.

3.4.3.b. Neutral valence – accuracy

The analysis revealed no significant main effect of posture on accuracy of recognising neutral valence, $F(1,59) = .020$, $p = .889$, $\eta_p^2 < .001$.

3.4.3.c. Positive valence – accuracy

An ANOVA revealed no significant differences between recognition of positive items under the open and slumped conditions, $F(1,59) = 3.401$, $p = .070$. Partial Eta squared revealed that approximately 5% of variance was explained by posture, $\eta_p^2 = .055$. However, this effect was not statistically significant.

3.4.4.d. Conclusion – accuracy

In summary, analyses on accuracy of valence judgments did not indicate any differences between performance under the open and slumped posture. While positive items revealed a stronger tendency toward an effect, this did not reach significance.

3.4.4. Main analyses: Reaction time

Table 5 demonstrates the average reaction times of judgments across the three valence categories.

Table 5. Mean (SD) reaction times (in ms) recognition judgments of negative, neutral and positive valence under open and slumped posture.

N=60	Negative	Neutral	Positive
Open posture	1393.49 (423.22)	1506.44 (388.95)	1436.33 (405.37)
Slumped posture	1395.33 (370.68)	1541.93 (388.83)	1345.95 (350.68)

Corresponding to the analyses on accuracy, effects of posture on reaction times were tested using three within-subjects ANOVAs. Again, analyses were Bonferroni corrected, with a resulting significance level of p = .017.

3.4.4.a. Negative valence – RT

Negative items revealed no significant differences based on posture condition, $F(1,59) = .003$, $p = .958$. Partial Eta squared also did not suggest any effect of posture, $\eta_p^2 < .001$.

3.4.4.a Neutral valence – RT

Analysis on neutral items revealed similar patterns. Reaction times for open posture did not significantly differ from those under slumped posture, $F(1.59) = .891$, $p = .349$, with small effect size, $\eta_p^2 = .015$.

3.4.4.c. Positive valence – RT

Analysis of positive sentences demonstrated a significant effect of posture on accuracy of judgments, $F(1,59) = 14.994$, $p < .001$. Reaction times under the slumped posture (M=1345,95, SD=350.68) were significantly faster than performance during open posture (M=1436.33, SD=405.37). In addition, Partial Eta squared showed a medium to large effect size, $\eta_p^2 = .203$. Therefore, the analysis suggests that the difference between open and slumped posture accounts for 20% of the variance between reaction times on positive items.

3.4.4.d. Conclusions – RT

Similarly to results from accuracy, analysis of negative and neutral valence showed no significant differences between the open and slumped posture. However, a significant effect was found on positive items, with medium to large effect size. Therefore, it can be concluded that posture manipulation can influence recognition of affect in sentences, however selectively based on specific valence, and limited to reaction times of judgements, rather than performance overall.

3.4.5. Exploratory analyses: Two-way analysis and interaction

Considering the two-factor repeated measures design of the study, it was important to conduct a two-way analysis, in order to confirm the findings of the separate univariate tests by valence. Thus, a 2x3 repeated measures ANOVA was run, with posture as first factor – levels open and slumped, and valence as the second factor – levels negative, neutral and positive.

3.4.5.a. Two-way analysis – accuracy

Firstly, a two-way ANOVA was run to determine how interaction between posture and valence affects accuracy measures. As the analysis was repeated measures, Mauchly's Test of Sphericity was consulted for all comparisons with more than two groups. The test was significant, revealing that data violates the assumption of sphericity for both valence, Mauchly's W = .889, $\chi 2$ (2) = 6.795, *p* = .033, and the interaction effect, Mauchly's W = .776, $\chi 2$ (2) = 14.716, *p* = .001. Thus, the analysis used values based on the Greenhouse-Geisser correction method for these two effects.

The ANOVA revealed no significant differences in accuracy between open and closed posture, $F(1,59) = .465$, $p = .498$, $\eta_p^2 = .008$. There was a significant main effect of valence, $F(2,106) = 6.924$, $p = .002$. Partial Eta squared showed a medium effect size, $\eta_p^2 = .105$. Post-hoc comparisons identified that negative items (M=96.9) were recognised with significantly higher accuracy than both neutral (M=94.2), $t(106) = 3.38$, $p = .001$, and positive sentences (M=93.9), $t(106) = 3.75$, p=.001. There were no significant differences between neutral and positive items, $t(106) = .30$, p=745. Significance was set by alpha level of .017, as Bonferroni adjustments were applied.

There was no significant interaction between posture and valence, $F(2,96) = 1.989$, $p = .151$, $\eta_p^2 = .033$. This suggests that posture did not affect accuracy of judgments differently based on the affective category of sentences. The results are illustrated in Figure 1.

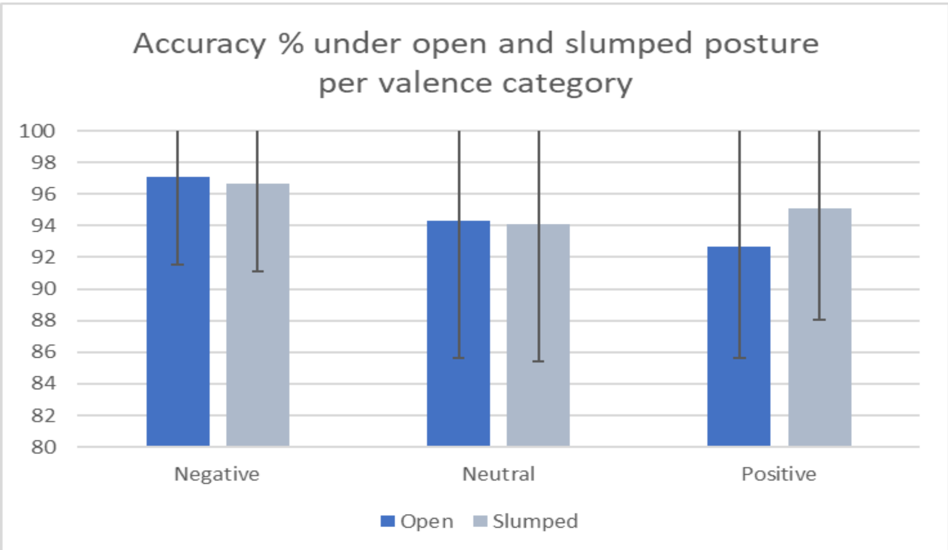

Figure 1. Accuracy on negative, neutral and positive items under open and slumped posture

3.4.5.b. Two-way analysis – RT

The analysis was repeated for the second performance measure – reaction time. Mauchly's Test of Sphericity was significant for neither valence, Mauchly's W = .989, $\chi2$ (2) = .634, p = .728, nor the interaction, Mauchly's W = .988, $\chi2$ (2) = .678, p = .712. Thus, the analysis could assume sphericity was not violated.

The ANOVA showed no significant main effect of posture, $F(1,59) = .435$, p=.512, η_p^2 =.007. Valence did reveal significant differences, $F(2,106) = 32.359$, $p < .001$. Partial Eta squared revealed that 35% of variance in scores was explained by valence, η_p^2 =. 354, showing a strong effect.

Tukey's HSD post-hoc analysis (Bonferroni adjusted significance at .017) suggested a different pattern to results on accuracy. Namely, negative RTs (M=1394.41) were significantly faster than neutral (M=1524.18), $t(118) = 6.85$, $p < .001$, but not positive (M=1391.14), $t(118) = .18$, $p = .856$. However, positive and neutral items were also significantly different, $t(118) = 6.77$, $p < .001$, with positive (M=1391.14) resulting in faster RTs than neutral (M=1524.18). This suggests that neutral items, in particular, were slower to recognise than strongly affected sentences.

The two-way analysis demonstrated a significant interaction between posture and valence, $F(2,118) = 8.511$, $p < .001$, with a medium effect size, η_p^2 =.126. Post-hoc comparisons were run to explore the interaction. Bonferroni corrections were applied for multiplicity of testing, resulting in α level of .017. The influence of posture did not significantly interact with negative valence, $t(118) = 0.05$, $p = .958$, nor with neutral, $t(118) = 0.94$, p=.349. However, open and slumped posture showed significantly different interactions with positive sentences, $t(118) = 3.87$, $p < .001$. The results can be observed in Figure 2.

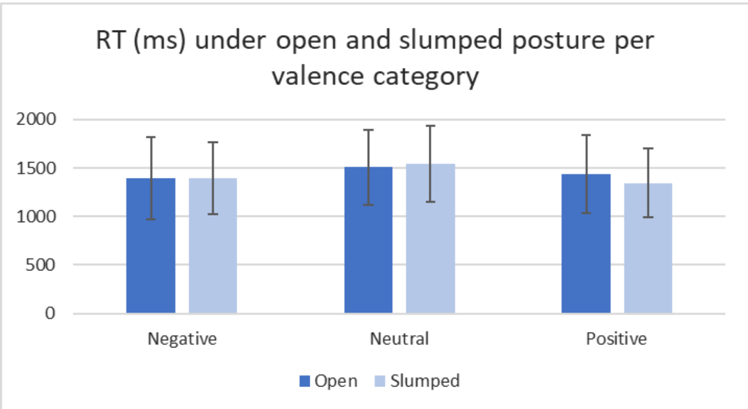

Figure 2. Reaction times (ms) for negative, neutral and positive items under open and slumped posture

3.4.5.c. Conclusions – Two-way analysis

In summary, results of the combined analysis confirm the findings of the one-way tests previously detailed (see *3.4.4. Main analysis: Accuracy* and *3.4.5. Main analysis: RT*). The two-way analysis further makes two important observations: open and slumped posture showed no inherent differences on either accuracy or reaction time; conversely, valence revealed strong and significant differences between categories.

In addition, the valence effect depended on the measure: differences were found for negative compared to neutral and positive items on accuracy, and none between the latter two, yet in reaction time it was neutral sentences that were slower than both other groups. This highlights that accuracy and reaction time might reflect different aspects of performance, especially with regards to detecting effects of valence.

The analyses found no interaction between posture and valence on accuracy, suggesting that recognition of affect in language was neither facilitated nor inhibited by congruent bodily feedback. Reaction time did reveal a significant interaction with medium effect size. However, further exploration demonstrated that this was only found for positive language, supporting the conclusions of the main analyses.

3.4.6. Exploratory analyses: Usual posture

Another variable collected was participant ratings for self-reported usual posture. It was considered that habitual posture could affect the way and the degree to which the experimental manipulation of posture could interact with emotion in language. Thus, this was taken into account as an additional, independent measures factor with three levels –open, slumped and mixed/neutral usual posture.

3.4.6.a. Usual posture – accuracy

Descriptive statistics show the sentence judgment accuracy for open and slumped posture per valence category – negative, neutral and positive, and per usual posture – open, slumped and mixed (Table 6).

Table 6. Mean accuracy percentage (SD) for experimental condition, valence and usual posture

N=60	Negative		Neutral		Positive	
	Open	**Slumped**	**Open**	**Slumped**	**Open**	**Slumped**
Usual O (N=11)	95 (8)	94 (7)	94 (8)	96 (7)	90 (12)	92 (7)

Usual S (N=21)	96 (5)	98 (3)	92 (10)	91 (10)	95 (10)	91 (10)
Usual M (N=27)	98 (4)	97 (5)	96 (7)	96 (9)	92 (7)	96 (9)

A 2x3x3 Mixed ANOVA was run. Mauchly's Test found no problems with sphericity for valence, Mauchly's W = .922, $\chi2$ (2) = 4.538, p = .103. However, sphericity was violated for the interaction between valence and posture, Mauchly's W = .763, $\chi2$ (2) = 15.179, p = .001, thus the interaction will be reported using Greenhouse-Geisser corrections.

The analysis found no main effect of posture $F(1,57) = .463$, p=.499, η_p^2 =.008. The posture manipulation also did not interact with participants' usual posture, $F(2,57) = .022$, p = .978, η_p^2 =.001, suggesting that the overall effects of the manipulation was not dependent on which of the postures participants usually adopted in their own time.

The analysis confirmed the significant main effect of valence, $F(2,114) = 6.194$, p=.004, with a small effect size, η_p^2 =.098. Tukey HSD tests using Bonferroni corrections showed significant differences between negative and neutral items, $t(114) = .023$, p= .019, as well as negative and positive $t(114) = .031$, p = .003, however not for the comparison between neutral and positive, $t(114) = .008$, p = 1. These effects are consistent with the patterns discovered in previous analyses.

However, a significant interaction was also found between the effect of valence and the new factor – usual posture, $F(4,114) = 3.475$, p = .010, η_p^2 =.109. As valence on its own had already been identified as a potential confound, and this interaction does not reflect the main focus of the study, the effect was not explored further in the current analysis.

The interaction between experimental posture and valence was not significant for accuracy of judgments, consistent with the results of prior analyses, $F(2,92) = 1.346$, p = .263, η_p^2 =.023, corrected using Greenhouse-Geisser method. In addition, the full interaction between all three factors – experimental posture, valence category and participant usual posture, was also non-significant, $F(4,114) = .537$, p = .709, η_p^2 =.019. This suggests that preference for and experience with either posture did not interact with how posture affects valence recognition under experimental conditions.

3.4.6.b. Usual posture – RT

Descriptives were run to show the average reaction times per posture, valence and usual posture.

Table 7. Means and SDs on RTs (in ms) for experimental condition, valence and usual posture

N=60	Negative		Neutral		Positive	
	Open	**Slumped**	**Open**	**Slumped**	**Open**	**Slumped**
Usual O	1390 (470)	1442 (478)	1412 (450)	1529 (497)	1330 (413)	1316 (426)
Usual S	1406 (392)	1375 (328)	1576 (384)	1574 (338)	1443 (409)	1363 (333)
Usual M	1385 (442)	1392 (368)	1492 (373)	1523 (391)	1473 (408)	1345 (351)

The 2x3x3 Mixed ANOVA on reaction times showed no violations of sphericity for either valence, Mauchly's W = .982, $\chi2$ (2) = 1.011, p =.603 or the posture and valence interaction, Mauchly's W = .988, $\chi2$ (2) = .673, p =.714. Thus, the analysis could proceed without corrections.

Corresponding with previous results, the analysis found no significant effect of posture manipulation, $F(1,57) = .034$, p=.854, η_p^2 =.001, or interaction between experimental and usual posture conditions, $F(2,57) = .751$, p = .476, η_p^2 =.026.

Valence once again revealed strong and significant effect on reaction time, $F(2,114) = 28.771$, $p < .001$, η_p^2 =.335. Post-hoc comparisons (Bonferroni corrected) showed that neutral items were slower than both negative, $t(114) = 119.091$, $p < .001$, and positive sentences, $t(114) = 139.203$, $p < .001$, but there were no differences between negative and positive themselves, $t(114) = 20.111$, $p = .862$. Similar to results on accuracy, the interaction between valence and participant usual posture was also significant, $F(4,114) = 2.495$, $p = .047$, η_p^2 =.080.

In regards to the main focus of the analysis – how the experimental posture manipulation affects performance on different valence levels, the ANOVA found a significant interaction, $F(2,114) = 6.674$, $p = .002$, with a medium effect size, η_p^2 =.105. However, usual posture did not interact with posture and valence, $F(4,114) = .519$, p = 722, η_p^2 =.018. This suggests that participants' usual posture did not interfere with the effects of the posture manipulation on reaction time, nor the selective effects on specific valence categories.

3.4.6.c. Usual posture – conclusions

The analysis including usual posture as an additional, between-groups factor confirmed some of the previously reported observations. Specifically, posture alone did not have an overall effect on accuracy and reaction time of judgements, but it affected recognition of positive sentences on RT only.

However, the analysis further showed that preferred posture, thought to be a potential confound, did not interact with the manipulation. In addition, this measure also failed to affect the interaction between the experimental posture and valence. Thus, the usual posture that participants assume did not interfere with the manipulation itself, nor with how successful it was in selectively facilitating or inhibiting performance based on valence.

One unexpected finding was that usual posture did interact with valence itself. Nevertheless, it is important to note the strong and consistently found main effect of valence. This makes it difficult to discern to what extent the interaction may be driven by the influence of valence. Considering this study was concerned with valence only in relation to its association with experimental posture, which was not, in turn, influenced by usual posture, this effect was not considered in more detail.

3.4.7. Exploratory analyses: Order of conditions

The final exploratory analysis considered another factor which could have acted as a potential confound, and masked the interaction between posture and valence in language. That was the order of the posture conditions. Namely, this exploration could identify any primacy or recency effects based on which posture was first. However, the variable was also a tangential measure of another aspect of order – whether either half of the experiment yielded better performance, regardless of the intended effects.

Thus, order was included as a between-group variable in a mixed 2x3x2 analysis. The two levels will be henceforth referred to as 'Open first' and 'Slumped first'. The level 'Open first' indicates that the open posture condition was undertaken first, and thus the performance under open condition would reflect the first half of the experiment, and under slumped – the second.

3.4.7.a. Order – accuracy

First, analysis on the accuracy of sentence judgments was run to determine whether the effects of posture and valence could be influenced by the order of conditions. Descriptive statistics were run to explore average accuracy rates (in %) under each combination of the three factors (see Table 8).

Table 8. Mean (SD) accuracy percentage for sentence judgments by order, posture and valence.

N=60	Negative		Neutral		Positive	
	Open	**Slumped**	**Open**	**Slumped**	**Open**	**Slumped**
Open 1st	98 (5)	97(5)	93 (11)	97 (6)	93 (10)	96 (7)
Slump 1st	96 (6)	96 (6)	96 (6)	91 (10)	93 (9)	94 (8)

A 2x3x2 Mixed ANOVA was conducted, with repeated factors posture and valence, and between-subjects factor order of conditions. Mauchley's Test identified violations of the assumption of sphericity for the two repeated observations: the effect of valence, Mauchly's W = .889, $\chi2$ (2) = 6.688, p = .035, and the interaction of valence and posture, Mauchly's W = .778, $\chi2$ (2) = 14.309, p = .001. Therefore, the Greenhouse-Geisser adjustment method was used in reporting these two effects.

The analysis did not identify any main differences in accuracy between open and slumped posture, $F(1,58) = .495$, $p = .485$, $\eta_p^2 = .008$. The influence of posture did interact with the order of conditions, $F(1,58) = 4.833$, $p = .032$, $\eta_p^2 = .077$. However, post-hoc comparisons revealed no significant pairwise differences. Comparisons between 'Open first' and 'Slumped first' order for the open posture, $t(58) = .007$, $p = .635$, and under the slumped condition, $t(58) = .030$, $p = .030$, did not reach the Bonferonni-adjusted criterion for significance at α=.025.

Results on the main effect of valence were consistent will all other analyses conducted. Accuracy reflected significant differences between the affective categories, $F(2,104) = 6.808$, $p = .002$, $\eta_p^2 = .105$. Tukey's HSD confirmed the previously found differences between negative and neutral, $t(104) = .027$, p=.002, and negative and positive items, $t(104) = .030$, $p = .001$, with no difference between neutral and positive, $t(104) = .003$, $p = .747$. The interaction between valence and the order of conditions was not significant, $F(2,116) = .010$, $p = .990$, $\eta_p^2 < .001$. This suggests that the influence of valence was not dependent on which condition was performed first, nor on the experimental halves.

Next, the interaction between valence and the experimental posture was reviewed. This revealed no significant differences in how posture affected accuracy of judgments based on the type of sentence, $F(2,95) = 2.102$, $p = .137$, $\eta_p^2 = .035$.

This could be explained by the full interaction between posture, valence and order. Specifically, there was a significant interaction between all three factors taken together, $F(2,116) = 4.350$, $p = .015$, $\eta_p^2 = .070$. This indicates that the relationship between posture and valence is dependent on the order of conditions. However, reviewing the pairwise comparisons showed that differences between individual levels of the factors did not reach significance at the α level of .008, which was determined through Bonferroni corrections for multiplicity of testing. Observed *p* values ranged from .030 to .689. These tests indicate that, while the order of conditions may influence the way posture affects valence judgments, this difference may not be detectible on individual levels. The mean accuracy per posture, valence category and order of condition can be seen in Figure 3.

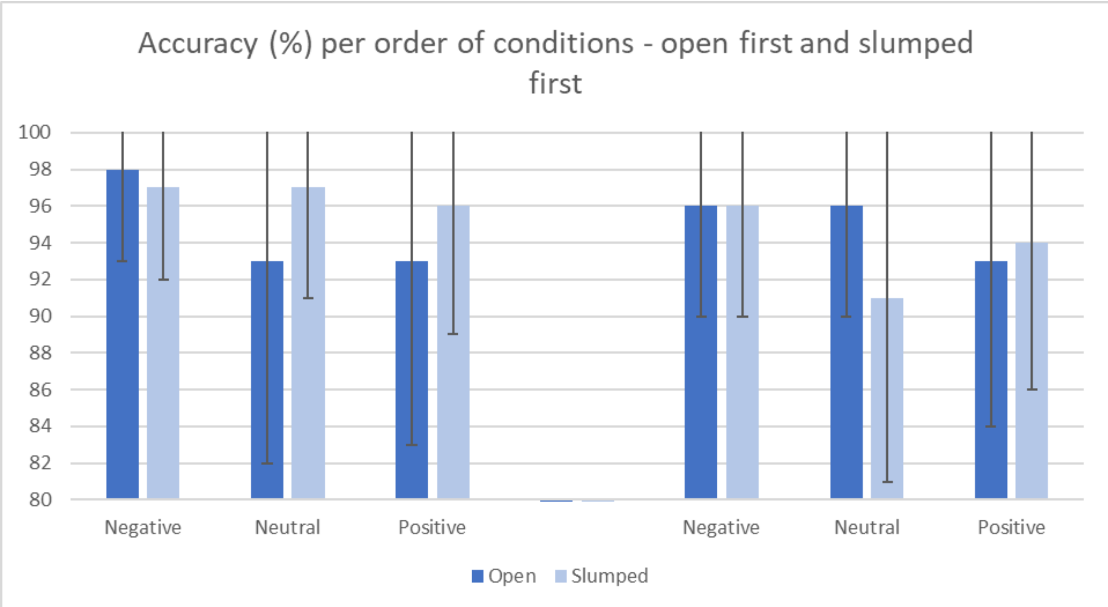

Figure 3. Accuracy in percentage for negative, neutral and positive sentences per posture condition, separated by order of condition

As Figure 3 illustrates, accuracy under the open and slumped posture showed different patterns based on order of conditions. Specifically, performance was higher for the posture which was second, and poorer for the first, regardless of condition. Although inferential tests did not reach significance, this potentially indicates that order affects performance through general mechanisms, such as practice.

3.4.7.b. Order – RT

The second performance measure – reaction time, was also investigated based on the three-way interaction between posture, valence and order. Table 6 demonstrates average reaction times based on each level of the three factors.

Table 9. Means (SD) on reaction times (in ms) of valence judgments, separated by order, valence and posture condition.

N=60	Negative		Neutral		Positive	
	Open	**Slumped**	**Open**	**Slumped**	**Open**	**Slumped**
Open 1st	1476 (396)	1322 (328)	1626 (362)	1467 (358)	1548 (421)	1367 (343)
Slump 1st	1311 (440)	1469 (401)	1387 (383)	1617 (409)	1325 (363)	1325 (363)

Next, a three-factor Mixed ANOVA was run to establish the individual effects and interaction of posture, valence and order. Mauchley's Test of Sphericity found no violations for valence, Mauchly's W = .961, χ2 (2) = 2.271, *p* = .321, or the interaction of posture and valence, Mauchly's W = .997, χ2 (2) = .190, *p* = .909. Thus, the analysis could proceed without corrections.

The ANOVA found no significant main effect of posture, $F(1,58) = .876$, $p = .353$, $\eta_p^2 = .015$, which is consistent with the observations of the two-way analysis. However, posture revealed a significant interaction with the order of conditions, $F(1,59) = 60.843$, $p < .001$. This also demonstrated a strong effect size, $\eta_p^2 = .512$, and observed power of 1, suggesting that more than 50% of variance could be explained by the interaction.

Tukey's HSD test was run to establish the pairwise comparisons between RT in the open and slumped posture, separated by the order of conditions. Results indicate that RT during open posture (M=1550.02) was significantly slower compared to the slumped posture (1385.03), when the open condition was first, $t(59) = 164.988$, $p < .001$. The comparison was also significant in the 'Slumped first' condition, $t(59) = 129.630$, $p < .001$, however there the open posture (M=1340.82) was faster than slumped (M=1470.45).

The next main effect to be considered was valence, which once again had a significant influence on performance, $F(2,116) = 35.151$, $p < .001$, with a strong effect, $\eta_p^2 = .377$, and observed power of 1. Post-hoc comparisons were consistent with the two-way analysis on RT: significant difference between neutral and both negative, $t(116) = 129.773$, $p < .001$, and positive items, $t(116) = 133.045$, $p < .001$, but not between positive and negative, $t(116) = 3.272$, $p = .841$. This highlights that, for reaction time, the difference in valence stems from neutral sentences, rather than the extreme valences.

The analysis also examined the interaction between valence and order of conditions. There was a significant effect, $F(2,116) = 6.090$, $p = .003$, $\eta_p^2 = .095$. Tukey's HSD comparisons of each valence level were performed for each order separately. Bonferroni-adjusted values, corrected for six simultaneous tests, resulted in an α level of .008.

Under the 'Open first' condition, significant differences were found between: negative (M=1398.98) and neutral items (M=1546.49), $t(116) = 147.507$, $p < .001$; and positive (M=1457.09) and neutral sentences, $t(116) = 89.403$, $p = .002$; but not between negative and positive, $t(116) = 58.105$, $p = .014$.

However, the 'Slumped first' condition revealed a slightly different pattern: significant differences between all levels, and with different magnitudes. Namely effect between: negative (M=1389.84) and neutral (M=1501.88), $t(116) = 112.039$, $p < .001$, but also positive (M=1325.19) compared to negative, $t(116) = 64.649$, $p = .007$, and to neutral items, $t(116) = 176.688$, $p < .001$.

Although these results do show some differences in the influence of valence depending on order, it is important to note they are mostly differences in magnitude, and continue to reflect the same strong tendencies driven by valence itself and observed throughout the experiment. This potentially indicates that valence, rather than order, is behind this effect.

The analysis also considered the interaction between posture and valence. It revealed a significant interaction effect, $F(2,116) = 9.250$, $p < .001$, with a medium effect size, $\eta_p^2 = .138$, and high observed power of .975. This suggests that, while considering the order of conditions, posture has specific and selective effects on reaction time based on distinct valence categories.

Nevertheless, looking at post-hoc comparisons reveals that the effect is driven by differences on positive items, namely open posture (M=1436.33) resulting in slower RTs than closed (M=1345.95), $t(116) = 90.378$, $p < .001$. No posture differences were found on negative, $t(116) = 1.843$, $p = .948$, and neutral sentences, $t(116) = 35.498$, $p = .209$. This demonstrates the same tendencies as revealed in the one-way (*3.4.4. Main analysis: RT*) and two-way (*3.4.5.b. Two-way analysis – RT*) analyses, even when the order of condition is considered.

This also necessitates to explore whether the interaction of posture and valence might also be dependent on the order conditions. The three-way interaction was significant, $F(2,116) = 6.121$, $p = .003$, $\eta_p^2 = .095$. Pairwise comparisons expand on which levels and pairings drive the interaction. The tests indicate that differences based on posture are evident in negative items under both the 'Open first', $t(116) = 154.448$, $p < .001$, and 'Slumped first' conditions, $t(116) = 158.134$, $p < .001$. Such posture effects are also found on neutral sentences for 'Open first', $t(116) = 159.761$, $p < .001$, and 'Slumped first' order, $t(116) = 230.757$, $p < .001$. However, on positive items a difference due to posture is observable only during the 'Open first' order, $t(116) = 180.756$, $p < .001$, but not when the slumped condition was first, $t(116) = .000$, $p = 1$.

This suggests that, while posture appeared to consistently interact with valence on all levels, this effect was nullified in positive items when the slumped position was first. This could possibly aid in explaining the consistent findings that positive items respond to posture differently than other categories. The results also raise the question whether effects of posture on negative and neutral items might be masked by their dependence on order, as well, or if the interaction is more complicated than previously observed. The mean reaction times are displayed in Figure 4.

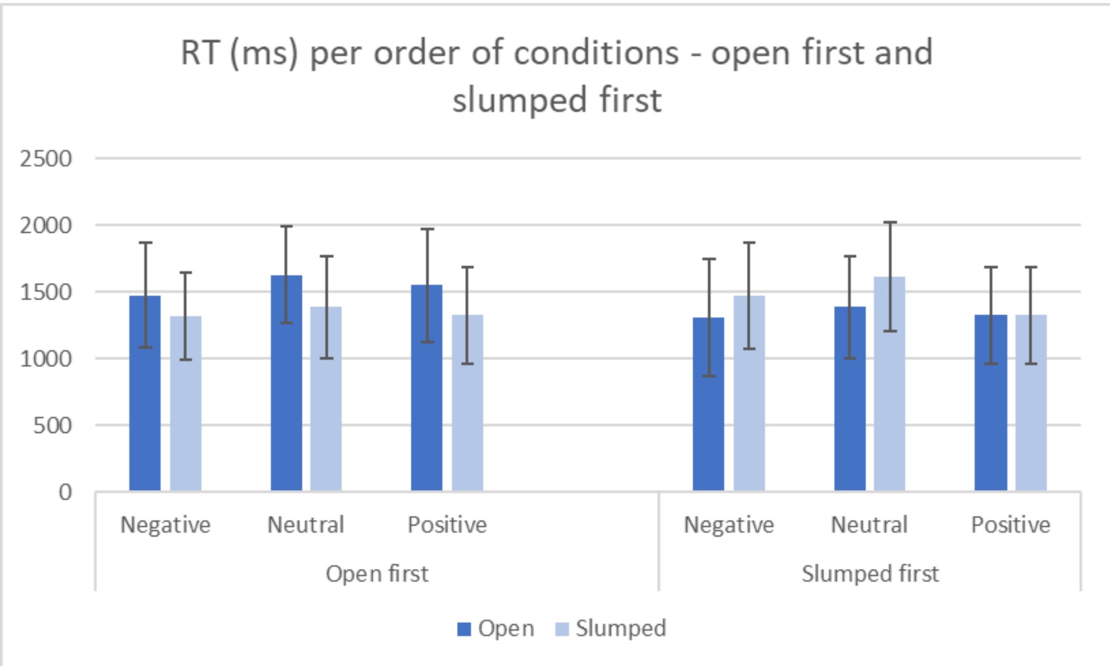

Figure 4. Reaction times (in milliseconds) for negative, neutral and positive sentences under open and slumped posture, separated by order of conditions.

As Figure 4 illustrates, the relationship between order, posture and valence follows a similar trend as the findings on accuracy (see *3.4.7.a. Order – accuracy*; see *Figure 3.*). Namely, the improvements by each posture are reversed based on its order: when open posture is first, it results in slower reaction times, however when it is second in order, it shows advantages to slumped posture, and vice versa. This indicates that the unexpected interaction between order and posture and/or valence might be at least partially due to practice effects and learning, and not an inherent interdependence.

This calls into question the argument above, namely that true effects of posture on negative and neutral items might be present, but masked by the involvement of order. Instead, it appears that it is the three-way interaction that carries the risk of confounding effects, as the posture differences in both the negative and neutral category appear to show reversal based on order (see Figure 4). Conversely, the differences on positive items, found throughout the main and exploratory analyses, appear to be diminished when practice effects by order intervene. Thus, it could be argued that: first, the posture differences on negative and neutral items are, in fact, the result of reversal due to practice only, and not a true effect, and; second, positive items are more resistant to practice effects and do not show the reversal by order, as they are already influenced by inherent effects of embodiment.

3.5. Discussion

3.5.1. Summary of results

In conclusion, the results of the study indicate several notable patterns. First, the main analyses show no significant differences between the open and slumped postures on accuracy. This was true for negative, neutral and positive sentences alike, showing no facilitation based on congruence. However, for reaction time there was a significant effect of posture on positive sentences. Conversely to expectation, the slumped posture resulted in faster recognition.

Second, the two-way exploratory analysis confirmed these patterns. There was no interaction between posture and valence on accuracy of judgments. Reaction time did reveal an interaction, but only for positive items.

Third, exploratory analyses examined whether participants' habitual posture could influence the success of the experimental manipulation. Usual posture did not have a significant effect on performance, nor an interaction with the posture manipulation. There was also no three-way interaction, suggesting that the effects of posture are not dependent on previous experience.

However, the second mixed analysis revealed that the order of conditions did influence the investigated relationship, in particular on reaction time. Specifically, performance was better under whichever condition was first, regardless of open or slumped. When order was included, differences appeared for all affective sentences. Nevertheless, this result is viewed with caution due to the overall effect of order, which is likely to mask the existing effects.

Thus, order is identified as a confounding variable, where the first half the experiment shows poorer performance regardless of posture condition or valence category. Another notable confound is valence itself. All exploratory analyses indicated a strong significant difference between affective items. On accuracy, negative items outperformed both other groups. On RT, negative and positive were faster than neutral. These consistent effects support the results of the pilot experiment, suggesting the presence of inherent differences in the recognition of negative, neutral and positive affect, prior to and in addition to any influences of posture.

This highlights that any statistical interactions between posture and valence may be primarily driven by valence itself, unless the categories are viewed separately as in the main analyses. In addition, the finding that posture affects recognition only on positive items is consistent with the valence differences identified, and suggests that positive language may not only be different, but also more sensitive to manipulation through embodied emotion. Conversely, negative and neutral affect showed resistance to manipulation from posture.

3.5.2. Interpretation of findings

The results partially support the study's expectations. The first hypothesis stated that negative sentences would be facilitated by slumped posture and inhibited by open. This was supported neither by accuracy nor reaction time as measures of performance. The second hypothesis predicted the opposite pattern for positive language. Although positive items did show significant differences in reaction time, these were in the opposite direction, namely, slumped posture resulting in faster judgments compared to open. Thus, the second hypothesis was also not supported. Hypothesis III suggested that neutral sentences would not be influenced by the posture manipulation in either direction, as they lack the affective component on which congruence effects would be based. This prediction was confirmed by results in both accuracy and reaction time.

These findings suggest that posture manipulation can affect recognition of valence in language, and that effects are selective based on emotion category. This supports the notion of embodiment in emotion and the effectiveness of body posture manipulation in eliciting embodiment effects. Nevertheless, the results did not follow the predicted direction, and were not consistent with the hypothesised congruency effects. Thus, further exploration is necessary before it can be concluded whether observed effects can be explained by typical embodiment or more complex mechanisms.

Furthermore, the experiment found some unexpected trends outside of the hypothesised outcomes. First, the differences between valence categories found in the pilot study were confirmed. The influence of valence was strong and consistent even when the confounding effects of usual posture and order were taken into account. This suggests that valence may to be considered more carefully and separately from posture in order to distinguish the way different emotion categories respond to embodied manipulation.

However, the second confound investigated – the usual posture of participants, did not influence the embodiment effects. Despite initial concerns that the posture manipulation may not be effective when incongruent with participants' own habitual posture, the evidence so far suggests that is not the case. This supports the study's premise that posture can affect emotion under short-term experimental conditions, even independently from prior experience. Thus, the current paradigm demonstrates a successful use of experimentally induced posture, and can elicit sufficient effects without longer interventions.

Lastly, order of conditions was unexpectedly identified as a confound. Although this appeared to interact with the desired interaction between posture and valence, the influence was suggestive of a methodological cause, namely practice effects. Therefore, this result is not interpreted in relation to the aims and hypotheses of the study, and is instead considered as a potential limitation below.

3.5.3. Link to literature

The results support trends found in the literature on embodied emotion. Research on facial manipulation has reported embodiment effects on comprehension, specifically recognition of positive and negative valence (Glenberg, Havas, Becker & Rinck, 2005; Havas, Glenberg & Rinck, 2007). Namely, a manipulation resembling smiling facilitated recognition of positive sentences and inhibited negative, while precluding smiling had the opposite influence. This was true without conscious knowledge that the facial position was meant to represent smiling, thus without awareness of the emotional component. Research also confirms that manipulations are appropriate in imitating regular affective feedback, as facial muscles respond in the same way as smiling (Niedenthal, Winkielman, Mondillon & Vermeulen, 2009).

The current results support these findings, demonstrating that embodied influences on emotion comprehension are elicited even though participants are not aware that the physical manipulations are intended to mimic emotional expression. This suggests a shared neuroanatomical or physiological link established through motor feedback, as proposed by embodiment theories (Barsalou, 2008).

In addition, the study extended the known effects to the entire body. Previous research using experimental manipulations was mainly focused on facial feedback of emotion. The role of the body was reviewed from the opposite direction, as a consequence of emotion re-experience. Nevertheless, it is useful to consider the current use of posture in the context of research on bodily emotion. First, the differences between open and slumped posture found in the experiment support the general distinction of separate patterns for positive and negative experience, respectively (Wallbott, 1998). These differences were previously identified through motion tracking during performance of action portraying emotion, and included distinctive characteristics such as collapsed upper body for negative affect and the converse openness for positive. This contrast is found across studies (Crane & Gross, 2013), supporting the current study's use of slumped and open posture. Research finds that different positive emotions, such as joy, pride and love share similar characteristics, while the same is true for negative affect, e.g., sadness, shame and anxiety (Gross, Crane & Fredrickson, 2010).

However, the current project combines these similar patterns into wider categorisation based on valence, and demonstrates that the shared properties between these emotions are sufficient to be generalised in that manner. The current study expands on the literature of embodiment by successfully using short-term still posture, instead of walking (Roether, Omlor, Christensen & Giese, 2009) or performance of actions (Gross et al., 2010), suggesting that embodiment effects are not limited to action and motion, but also states when sufficient relevant information is present.

The study also expands on full-body research by demonstrating effects on language, which has been under-researched in the area. Previous studies have explored whether producing emotional language can affect posture, but not the converse effects. Oosterwijk, Rotteveel, Fischer and Hess (2009) find that generating positive and negative words results in postural changes compared to neutral words, especially strong for negative items. Similarly, Kang and Gross (2015) report changes in sit-to-walk patterns when participants write down and re-imagine autobiographical stories of positive, negative and neutral affect. These studies indicate that posture is reactive to language, and that emotional information accessible through language has sufficient shared cognitive representation to elicit congruent bodily states, even in the absence of other emotional stimuli. However, this does not inform research of the opposite direction, posture affecting language processing, nor whether self-generation of language and reliance on autobiographical experience are necessary for the effects to emerge. Conversely, the present experiment confirms the bidirectional nature of the relationship, demonstrating that posture affects language, and additionally in sentences designed specifically to avoid self-reference and reflect more general everyday uses of language. However, the current study found the opposite direction of results, with congruent posture inhibiting positive sentences. This should be interpreted in support of previous research on posture with some caution. The contradictory results could be attributed to the difference in language tasks used, i.e., generating self-referent words or stories versus comprehension of written sentences. Previous research has shown that self-referential and other-referential affective processing show distinct patterns of neural activation, with the right dorsomedial prefrontal cortex responding only to self-referential language (Fossati et al., 2003). Thus, tasks that do not refer to the self may utilise different neural resources, which could explain the presence of competition instead of facilitation.

It is important to consider that the findings of the current study do not necessarily reflect emotion re-experience, as there was no direct measure of affective response. However, this is not considered problematic for two reasons.

First, the project aimed to investigate cognitive responses related to comprehension and language, rather than felt emotion. Although past experience of affect is one of the mechanisms suggested behind the embodiment of emotion (Prinz, 2005), this process is considered longitudinal and not dependent on immediate affective response. Further, it is possible that embodied associations are constructed without conscious awareness an emotion is experienced. Riskind (1984) and Riskind and Gotay (1982) find that posture manipulations do not necessarily influence feelings of sadness, however result in cognitive distortions associated with depression, regardless of self-report measures.

Second, research has documented self-reported experience and neurophysiological reactivity of congruent emotions during embodied manipulations. During facial feedback, participants who display deeper simulation of the unknown smiling expression, e.g., the so-called Duchenne smile, also report increased autonomic arousal (Soussignan, 2002). Duclos, Stern, Sexter, Schneider, Laird (1989) report that both facial and body manipulations heighten perceived experience of emotion, including sadness, anger, fear, disgust. Performance, observation and mental imagery of movements associated with sadness were found to significantly increase sad feelings (Shafir, Taylor, Atkinson, Langenecker & Zubieta, 2013), demonstrating typical embodiment effects.

This has also been found in neurological measures of cognitive reactivity. Watching emotional movie-clips elicited stronger activation for negative and positive, but not neutral affect in hypothalamus, somatosensory and fronto-cortical areas (Viinikainen, Glerean, Jääskeläinen, Kettunen, Sam, & Nummenmaa, 2012). Schneider et al. (2014) review brain oxygenation during observation of fearful, angry, sad, happy or neutral walks. Using functional near-infrared spectroscopy, they report increased activation for emotional compared to neutral stimuli, and particular areas responding to emotion in right occipito-temporal, left temporal and temporo-parietal areas. The effect was stronger during a task requiring explicit recognition of emotion, suggesting that the parallel task in the current experiment is likely to also involve similar neurological re-experience. Thus, despite the absence of self-report measures of affective response, involving bodily and language task with clear emotional components is likely to have induced emotion and involved similar brain areas.

Overall, the research field supports the trends of the current experiment: on the one hand, the embodied effects on language comprehension found for facial feedback; and on the other, the distinction of slumped versus open posture, corresponding to negative and positive emotion. The present project extends the literature by combining these separate strands of research.

However, the literature provides one context in which the current results offer more confusion than clarity. That concerns the posture effects on positive items, and specifically their direction. Previous findings on facial manipulation suggest that the effects are based on congruence: namely, as smiling is associated with positive emotion, it facilitates recognition of positive affect and inhibits recognition of negative language (Glenberg et al., 2005; Havas et al., 2007). The congruence mechanism is suggested to rely on simultaneous, shared recruitment of neural resources, which facilitates consequent co-activation, and in turn makes the process of retrieving information more efficient. This is consistent with the principles of embodied cognition and the typical effects found in motor cognition and language: facilitations when the direction of motor action coincides with the implied direction in language, and inhibition for converse directions (Glenberg & Kaschak, 2002; Zwaan & Taylor, 2006).

However, the current results show the opposite pattern – positive sentences improved by slumped posture, which is associated with negative emotion. This suggests a mechanism of competition, instead of facilitated recruitment. Although such effects have been found in the embodied cognition literature, they are inconsistent with the emotion research discussed above. Thus, it may be impossible to draw conclusions on the basis of the current study alone. Future experiments need to be conducted with the same materials, and to investigate other aspects of cognition, such as implicit comprehension and processing of full text.

One explanation for the unexpected effect is that task demands require explicit processing of emotion. However, if open posture does elicit automatic associations with positive affect, this emotional component would already be engaged. It can be argued that, instead of priming, a competition for neural resource occurs, where the network needs to disengage from the emotional information offered by the posture, in order to engage in the task requiring to distinguish one valence from another. This highlights the importance of investigating implicit processing in further experiments, and exploring whether removing the necessity of explicit valence recognition also reduces the effects of competition.

Nevertheless, competition does not explain why posture influences were found only on positive, and not negative items, as the same mechanisms are theorised behind both. Thus, the selective effects can be explained by sensitivity to influence. Specifically, during pilot testing and in the current results, negative items consistently showed the best performance. It is possible that ceiling effects occur, where negative sentences show high performance independent of any facilitation effects. In addition, evidence suggests that positive emotion and positive language may be different and less stable than the opposing valence. Fredrickson (1998) observes that distinct positive emotions are fewer in number than the negative subcategories, and more diffuse in definition. Further, positive emotions have been reported to show weaker neural and physiological reactivity (Ellsworth & Smith, 1988). Gross et al. (2010) also suggest that emotion from the body is more poorly recognised for positive affect. The neural processing of positive and negative words also differs (Fossati et al., 2003). Contrary to Ellsworth and Smith (1988), evidence from language suggests that neural reactivity to positive words is stronger than negative words, and event-related potentials are more sensitive to differences in valence strength between mildly positive and strongly positive language (Yang et al., 2013). While research disagrees whether positive emotion shows stronger or weaker activation, the differences between valence categories are consistently observed and thus explain the selective reactivity found in this experiment.

Fredrickson (1998) explains these effects in relation to evolution. Specifically, research and theory suggest emotions are primarily focused on preparing specific action, e.g., attack or escape. Positive emotions are not consistent with this model of direct response. Instead, actions prompted by positive emotions are suggested to be nonspecific. Thus, positive effect is less stable and independent in nature, potentially making it more susceptible to influence. Perhaps it is this sensitivity to external influences that allows positive emotion to reflect embodiment effects, which requires more investigation in future experiments.

Overall, the current study supports the notion of embodiment in language and emotion. The fundamental premise of embodiment is that abstract cognitive processing, including comprehension, are not independent from physical states, but rather supported by them (Barsalou, 2008). This is further extended by Prinz (2005) to suggest that emotion comprehension is informed by the physical states associated with it. Thus, the present findings that valence recognition can be selectively influenced by posture indicates that affective cognition is not independent from the body, but supported and potentially dependent on it, supporting the premises of embodied emotion.

3.5.4. Strengths and limitations

The study experienced some limitations. First, while inherent differences between positive, negative and neutral language may be expected, this poses a potential confound, as the relationship between posture and valence may not be uniform across different affective categories. The results of the experiment support this, showing selective effects on positive sentences only. As discussed previously, research indicates that the physiological, neutral and cognitive mechanisms behind positive emotion may differ from negative. However, this needs to be considered in the planning of future experiments, as well as in the interpretation of current findings, and indicates that the embodiment effects may not be generalisable to emotion comprehension as a whole.

Furthermore, some methodological issues were present. The order effects demonstrate that performance was poorer in the first half of the experiment. This may be explained by the complex design, which necessitated the switch of response codes between the first and second halves (see *3.3.4. Procedure*). Although it was initially expected this could damage responses in the second half, after the switch, results suggest the opposite – the practice effects were sufficient to improve performance, even after a complete shift of response. This highlights the importance of providing sufficient practice and simplifying the paradigm in order to optimise performance. These factors need to be considered for further experiments.

Additionally, the posture manipulations adopted by participants were not always uniform. Although volunteers were shown examples of the postures and were encouraged to sit in a uniform way, individual differences occurred. For example, slumped posture was reflected by different levels of curving of the shoulders, or a few centimetre difference in spine tilt and head elevation. Similarly, some participants adopted an open posture by sitting upright at a little over 90 degrees from the chair, while others leaned back at a wider angle. This was most likely due to personal experience and comfort of individual participants. Despite costing a level of experimental control, allowing participants limited freedom in their sitting posture maintained physical comfort and avoided strain.

Nevertheless, previous research identified emotional correlates in the body has suggested exact angles of the head, shoulders and spine as important in differentiating between affective states (Gross, Crane & Fredrickson, 2010). In addition, there might be inherent differences in the strength of activation between posture associated with different emotions. Namely, Nummenmaa, Glerean, Hari and Hietanen (2014) use heat maps to demonstrate where and with what strength emotion is experienced in the body. Results suggest that positive emotions often result in higher activation than negative, and more concentrated in the upper body. Thus, the open and slumped postures may not be experienced in comparable ways. Moreover, most research showing distinctive patterns for positive and negative affect uses body movement and action, not only still position (Crane & Gross, 2013). Although these differences could affect the success of the manipulation, exploring participants' own emotional experience was beyond the goals of the project, namely cognitive, and not affective influences, and will remain for future developments.

Despite the observed methodological issues, the study also revealed several strengths, and helped create a basis for the exploration of full-body effects on emotion comprehension in language. The current paradigm successfully extended previously used methodologies, such as the linguistic valence recognition task employed in research on faces (Glenberg et al., 2005; Havas et al., 2007), and posture manipulations created by Riskind and Gotay (1982), combined in a novel design.

In particular, the current study also aimed to modify previously used materials using stricter, statistically justified criteria. Research has employed similar items in the study of language before, specifically positive and negative sentences (Glenberg et al., 2005; Havas et al., 2007) and short vignettes portraying different emotions (Nummenmaa et al., 2014). However, these examples did not consider several important linguistic and valence properties. Materials often included items of varying word- and syllable-lengths, introducing confounds between items and making comparisons of reaction time particularly difficult. Neutral language was not considered, making generalisations to ecologically valid text problematic. Instead, the current materials allow for the exploration of valence beyond a forced dichotomous choice of positive versus negative.

In addition, previous items were classified on valence using arbitrary criteria, and not accounting for the individual meanings of words. This means that a word of negative valence could 'contaminate' a positive sentence, especially considering eye fixations on key words during reading. Instead, the current paradigm considers each word in the sentence, contains no mix between opposite valences, and uses statistical cut-offs based on participant-given ratings of valence, arousal and dominance (Warriner, Kuperman & Brysbaert, 2013). As such, the current study improves on previously used methods, introducing more control over items and clearer valence distinctions.

The experiment also expands on posture manipulations used in research. The successful use of open and slumped posture to elicit emotion effects supports previous findings (Riskind, 1984; Riskind and Gotay, 1982) explored the emotional experience and cognitive performance under similar manipulations, and found that slumped posture inhibited perseverance on a maze task. However, the present study extends these results to different elements of cognition, namely language comprehension, and shows evidence of emotion embodiment beyond direct affective experience.

3.5.5. Conclusions and future directions

The present study aimed to explore the association between the embodiment of emotion and comprehension of affective information in language. The study employed a manipulation of body posture to influence performance on a valence recognition task. It was hypothesised that posture involves re-experience of emotionally relevant information, and would thus facilitate processing of congruent affective information, and inhibit incongruent information.

The results of the study support the role of embodiment in language comprehension. However, the effects are detectible only in selective measures, and reveal the opposite to expected direction. Namely, reaction time on positive sentences showed an advantage for the slumped over open posture. Thus, posture was shown to elicit facilitatory effects, but not based on congruence. In addition, strong differences between valence categories at baseline, as well as methodological issues such as order effects, may have influenced results.

Therefore, further experiments are necessary to understand the extent to which posture influences comprehension and the embodied mechanisms responsible for the effect. First, methodological adaptations need to be undertaken to reduce order effects. Thus, a simplified experimental paradigm and longer practice sessions will be adopted for further stages of the project. Second, the hypotheses and planned analysis of future studies will be informed by the current results. Namely, reaction time was identified as the most promising measure of performance. Valence was confirmed to show consistent differences, supporting the use of separate hypotheses for negative, neutral and positive items. Additionally, due to the surprising direction of the current results, Study II will not use a directional hypothesis. Third, importantly, future experiments will expand on both the present study and previous research by focusing on implicit effects of posture. If facilitatory effects are shown when affective information is present, but not necessary for the task, this would indicate that embodiment supports not only direct processing of emotion that appears in sentences, but also overall comprehension of language.

In conclusion, the present study was successful in exploring explicit comprehension of emotion in language, and demonstrated that bodily feedback is used when making decisions about affective information. However, it is important to note that current understanding of the process is limited, as effects are found only in positive language, and the direction, and thus mechanism of the facilitation have been put into question. It is necessary to explore this further by expanding the range of cognitive processes investigated and observing different types of comprehension.

4. Chapter IV. Study II: The role of bodily feedback in memory of emotion words

4.1 Overview

The current chapter will discuss Study 2 of the project, which extends the findings of Study 1 to memory of emotion content beyond simple recognition. First, literature on memory of language will be discussed, explaining the role of valence in memory. Particular focus will be given to research on memory under physical conditions, such as walking, sitting and other movements, and their proposed interaction with valence categories. The aims of the study will follow closely from this, but incorporating the procedure used in Study 1 and the continued focus on ecologically valid sentences. The hypotheses for differential effects based on valence will be discussed based on the original assumptions detailed in Chapter I, and not in relation to the surprising results of Study 1, as the implicit memory process explored in this study does not follow the explicit valence recognition discussed previously. Thus, the study hypothesises a facilitation effect for valence-posture congruence.

The Method will detail the procedure, following from Study 1, and identify the newly added protocols. Then, main results of valence categories explored separately will be reported. The results confirm the importance of positive items, but demonstrate a facilitatory effect of open posture, which contradicts the findings of Study 1. Exploratory two-factor analyses will be reported to confirm whether main effects of posture and valence may confound results, and to explore the measure of sentence reading times.

The implications of these findings will be discussed, in particular explanations for the contradictory direction of the effects in Study 1 and Study 2. This will also be related to findings from previous literature, where the results presented here confirm facilitation of memory for congruent items. This leads to the suggestion of differential processes for emotion recognition and emotion memory.

4.2. Introduction Study 2

In the previous chapter, Study 1 discussed the role of embodiment in processing language, and demonstrated that posture manipulation interferes with reaction time on recognition of positive sentences. This demonstrates that body posture can be used as a successful source of embodiments and extends previous findings on the face only (Glenberg & Kaschak, 2002;

Glenberg, Havas, Becker & Rinck, 2005). The uniqueness of positive language was also revealed, suggesting that embodiment may be more strongly evident in this emotional valence category compared to others. However, this does not explain whether the observed effects are isolated to explicit recognition of valence and categorising items as positive, negative and neutral, or also involves finer distinctions of semantic content. Exploring deeper semantic processing would necessitate a different task where broad valence categories are not the main focus.

4.2.1. Identification of target processes and tasks

Traditionally, research has used measures such as lexical decision to investigate phonological and lexical access (Yap, Sibley, Balota, Ratcliff, & Rueckl, 2015) and even semantic priming (Neely, Keefe, & Ross, 1989; Perea, & Rosa, (2002). There is long-standing evidence that semantic information, such as associations of meaning between word pairs, is accessed even during tasks where participants need only identify whether a string of letters is a real word or not (Fischler, 1977; James, 1975). However, priming was identified only for words that form direct associations, and not general semantic similarity (Joordens, & Becker, 1997), i.e., when the distractor non-words are pseudophonemes related to the target word, and not other phonologically legal non-words. This suggests that facilitation may be achieved through recognition of familiar lexical pairs rather than access to deeper semantic representation. Comprehension of emotional information is suggested to overlap between the body and the mind through physical experience (Prinz, 2005), which implies deep and experiential semantic encoding and any associations are based on content, and not frequency (Meteyard, Cuadrado, Bahrami, & Vigliocco, 2012). Evidence also demonstrates that phonological access and controlled retrieval of semantic information map onto specific subdivisions within Broca's area (Devlin, Matthews, & Rushworth, 2003). This confirms that semantic information is represented differently in the brain in terms of conceptualisation and neural substrates, and tasks that do not directly target semantics may be reflective of a slightly different process. Thus, in order to explore embodiment beyond category recognition, tasks with semantic and not lexical focus are needed.

In this context it is particularly relevant to identify tasks that are suitable not only for semantic representation as a whole, but also to the purposes of embodiment research. Bergen (2007) reviews linguistic experimental methods that lend themselves to the simulatory re-experience necessary for embodiment. Bergen proposes that words referring to motor action should ideally refer to actions opposite in direction on the muscle level, such as opening versus closing an arm and other pairs of the away-towards or open-closed dimensions. This suggestion is closely reflective of the overall methodology for the current experiment, specifically the open/closed body postures which are intended to activate contrasting emotion associations.

Past research into action representation primarily uses verbs (Kemmerer & Gonzalez-Castillo, 2010; Kemmerer, Castillo, Talavage, Patterson & Wiley, 2008). One established verb task is the Semantic Similarity Judgment Test (SSJT), which demonstrates differential processing of hand-related, body, auditory and abstract verbs and is often used to demonstrate the distinction of abstract versus concrete words (Kemmerer et al., 2008). The SSJT consistently shows embodied effects, where processing of hand- and body-related verbs is impaired for participants with damage to the motor cortices (Kemmerer, Miller, MacPherson, Huber & Tranel, 2013). The task employs a probe – a verb within a specific category, such as '*grasp*' for hand verbs, a target and a distractor. Importantly, the target and distractor belong to the same category, i.e., hand-related verbs, and the task is thus appropriate for investigating fine semantic distinctions.

However, the current project explicitly intended to use ecologically valid language that is not limited to verbs only, and is not restricted to single words in isolation from the broader context of a sentence. Thus, the principles identified in previous embodied research need to be adapted and incorporated within the protocols already used in Study 1. Continuity and interpretation between the studies would be improved if they employ the same methodology and materials with minimum adaptation. Development and validation of the 90 emotive sentences presented in Chapters II and III was a central aim of this project, and employed different criteria for both experimental control and ecological generalisability. Thus, it was concluded the most appropriate approach would be to use the same materials and develop a secondary task that taps into deeper, more specific semantic content beyond valence category.

The stimuli in question included at least several words per target emotion category, organised into grammatical sentences. This lends the items to a memory task that combines the rich, contextual emotional information of the 90 sentences with the practicalities of a target-distractor paradigm. Such a paradigm would follow from the validated lexical decision task discussed previously, and especially from the Semantic Similarity Judgment Test, by utilising two words of comparable semantic category, but separated by finer differences in meaning. In the sentence '*She kissed her husband with warm affection*', suitable target and distractor words would be '*affection*' and '*wisdom*', as both reveal comparable positive content based on existing ratings (Warriner, Kuperman & Brysbaert, 2013), but still have different meaning.

While such words would also differ on some lexical levels, such as phonology, using the same grammatical category, i.e., noun, verb, adjective, makes the distractor grammatically legal, and still maintains a higher level of plausibility than a lexical task where the distractor is a non-word. This was the paradigm selected for Study 2, following on from the experimental practices proposed by Bergen (2007) and the SSJT task (Kemmerer et al., 2008).

While the SSJT is purely a semantic comprehension task, the current study will involve reading sentences and retaining this information over a short period of time until the target and distractor words are presented. This introduces a memory component, where, if anything, comprehension will be a secondary aspects that supports 'pure' verbal memory. Thus, literature on memory theories and data on emotion memory will be discussed next.

4.2.2. Memory and language

The topic of memory has seen some contradiction in defining separate processes within the broad term 'memory', and explaining the difference between short-term, long-term and working memory (Cowan, 2008). One way to distinguish these processes would be the length of the retention period, but other factors need to be accounted for, including the intensity of the memory load, i.e., how much information needs to be memorised, and the level of reliance on other cognitive processes such as attention. While long-term memory is indefinite and informed by experience, short-term memory (STM) refers to retaining information over a period of seconds up to minutes. Distinguishing working memory (WM) from STM is more difficult, with comparable retention periods and span capacities. WM is most often defined by an active component, i.e., manipulating as well as remembering items, and this involves executive resources such as attentional control (Cowan, 2008). While remembering a sequence of seven words would constitute a STM task, WM would also be involved in remembering items in reverse order, or performing a secondary task simultaneously.

In the context of the current chapter, working memory will be defined as memory combined with attentional resources, such as recalling a target item from a larger stimulus set. Here, long-term memory will also be discussed as an 'access point' to semantic content (Klimesch, 1994), whereby familiar conceptual representations are stored in long-term memory and then selectively activated during WM performance. Research confirms that long-term memory can be used to activate or support semantic representations even during a short retention period of verbal information (Cameron, Haarmann, Grafman & Ruchkin, 2005). Haarmann and Usher (2001) report that semantics are used for maintaining memory storage within a narrow time window.

There is also evidence that WM interacts with emotion, where an experimentally induced mood can influence ratings of pleasantness on negative, positive and neutral words (Baddeley, Banse, Huang, & Page, 2012). While such an effect would be based on current mood, and not necessarily embodied feedback, the process likely reflects the same interaction of emotional content presented in the verbal task and emotion content from other internal sources, such as self-monitoring of physical and emotional states. Thus, it is reasonable to expect that a verbal WM task could activate semantic information such as emotion category or physical feedback of emotion, when such information is relevant.

To fully contextualise the current paradigm within the literature, theoretical models of WM should be considered. The most well-known model was proposed by Baddeley and Hitch (1974) and updated in 1994. It suggested two separate processes for visuo-spatial and verbal information. While each of these 'slave systems' was proposed to operate independently, the model also states central resources guide information to and from these modality-specific systems. Later editions of the model introduce the episodic buffer, through which information passes from perception to WM (Baddeley, 2000).

Alternative models by Logie (Logie & Logie, 1995; Logie & Van Der Meulen, 2009) describe a very similar system, further specifying that verbal and visual processors may have different connections to executive resources and episodic buffer. A final model by Cowan (1999) suggested the so-called 'embedded processes', whereby visual and verbal stimuli are processed the same way through allocation of attentional resources. The model specifies that the most highly active focus of attention holds a very limited number of items which consequently decay and become partially activated. However, this secondary process of partial activation is also discussed with links to long-term memory, which becomes important when we attempt to understand whether semantic processes are involved in memory.

Updated models of working memory acknowledge the role of applying semantics to visual or verbal content for the purpose of categorisation and organisation, i.e., chunking (Baddeley, 2009, 2012; Logie, 2009, 2011). This means that a visual pattern can be conceptualised as a familiar shape from daily life, or a random string of words can be organised in a narrative. These semantic strategies improve WM by activating links to long-term memory representations of familiar concepts (as seen in the Baddeley, 2012, and Logie, 2011 models).

The role of semantics is visible in the process known as 'chunking'. Chunking is proposed to improve memory by turning multiple pieces of data, i.e., several words, into a single 'chunk' of information. Suggested mechanisms include recovering and reconstructing traces of memory from short-term storage, or, alternatively, compressing multiple items into a single representation (Norris, Kalm & Hall, 2019). Interestingly, it was demonstrated that immediate recall of sentences is better than memory for unrelated word lists (Baddeley, Hitch & Allen, 2009) – a benefit of 'chunking' present even when distractor attentional tasks are used. Chunking is an effective tool of verbal memory even in clinical populations such as Alzheimer's Disease (Huntley, Bor, Hampshire, Owen & Howard, 2011) and Korsakoff's syndrome (Haj, Kessels, Urso & Nandrino, 2020). Evidence suggests that chunking improves memory regardless of rehearsal and distractor tasks, and WM reveals no limit of how many chunks can be stored, compared to limited storage of individual items (Thalmann, Souza & Oberauer, 2019). This suggests that chunking information in a meaningful pattern reduces demands on working memory by 'freeing' space through organisation. Thus, sentences are as appropriate for WM task as words, and this can activate semantic representation, if we assume that chunking is performed on the semantic level.

This leads to two conclusions. First, using a working memory paradigm to engage verbal semantics is a viable option. Second, sentences can be used in WM tasks without impaired performance, and potentially even facilitate conceptual and contextual representation of the items. Within the current paradigm, sentences may encourage applying chunking and long-term memory semantics, which would engage the representation of emotion content and thus ensure access to relevant embodied representations.

In summary, memory of emotion words explored in Study 2 will be broadly conceptualised in the context of working memory models, insofar as WM overlaps with the semantic processes which are the main focus of this doctoral project. This project aims to explore embodiment of emotional information, specifically the activation of relevant semantic content to support memory. It is suggested that full-bodied, experiential representations, including physical information from the body, will be utilised to support the memory process. The mechanism proposed here is that: a) memory of sentences and word recognition will activate semantic representation from long-term memory; b) this activation will be richer and more embodied the more difficult the task, i.e., recognising target word from a distractor of comparable valence, where finer semantic differences need to be applied from long-term memory; c) this makes embodied emotional information relevant and thus facilitates its simulation. Next, data will be discussed to establish closer links between memory processes and embodied emotion.

4.2.3. Memory and emotion

Literature on memory has consistently established its association with emotional states, including mood. Exploring mood congruency, i.e., remembering information consistent with one's own current state, is heavily researched (Blaney, 1986), but may not reflect affective processes beyond immediate mood. Suggested implications of the memory-emotion association span from neuroscience and psychobiology to clinical and social contexts (Reisberg & Hertel, 2003). However, the role of distinct sources of biological feedback, such as physiology compared to muscle activation, is less understood. Embodiment can shed a light of some of these processes through its strong links with sensation and action (see Chapter II).

First, it is established that emotion and its intensity can affect memory on language measures. Dietrich et al. (2001) demonstrate that recall of negative and positive items is higher than neutral on a verbal recognition task. Altarriba, Bauer & Benvenuto (1999) show that emotion words can be distinguished from abstract and concrete words. While concreteness and contextual access were rated as lower than other categories, following experiments established that affective words are more easily remembered (Altarriba & Bauer, 2004). This was discussed in support of semantic network models, which specify that contextual links that are more in number or stronger in activation would result in easier retrieval (de Groot, 1989). This is consistent with the expectations of embodiment, where physical experience provides richer contextual information that supports comprehension. Based on this mechanism we can predict that providing easier access to embodied semantics, or, conversely, precluding access, would impact memory performance.

There is some evidence that experimental manipulations of body feedback can affect recall. Autobiographical memory is improved when body position during memory retrieval is consistent with position of memory encoding (Dijkstra, Kaschak & Zwaan (2007), such as remembering being at the dentist while lying down. Riskind (1983) investigated memory of emotion-laden autobiographical life events. The study employed manipulations of both the body and the face to reflect 'positive' and 'negative' physical positions. Smiling or an expansive body position reflected positive emotion. Results indicate congruency effects, where latency of recall was improved when the physical condition matched the valence of memory. This effect was particularly strong for positive items, and persisted when current mood was controlled for, thus indicating a facilitation through semantic overlap, and not surface mood characteristics. The role of mood appears to be dependent on the nature of materials used, with narrative-based language more susceptible to mood effects compared to lists (Riskind, 1989).

Kang and Gross (2015) used a similar autobiographic technique to explore embodiment from the opposite direction – whether emotion re-experience can induce congruent body responses. After a short writing task, participants were asked to stand up from a chair and start walking. The movement from sitting to walking position was recorded using motion tracking, and revealed emotion-congruent patterns. The speed and range of motion were strong indicators of emotion, with sadness resulting in slower motion, while happiness and anger, both known for an expansive nature, showing higher speed, increased forward and backward movements and more 'jerkiness'. Importantly, sit-to-walk patterns for emotion were different from neutral, indicating that the congruency effect is not possible when emotive information is absent.

Generating affective words has also been shown to affect body representations of emotional content. Oosterwijk, Rotteveel, Fischer and Hess (2009) explore this in relation to sitting posture. Participants were asked to generate words from four categories – control neutral, pride and disappointment. Self-report indicated that participants found generation of emotive words more difficult than neutral, however the task did successfully activate autobiographic memory for both affective conditions. Generating disappointment words led to decreased postural height, i.e. 'slumping', which included continuous decrease throughout the task. While the pride condition did not show a corresponding continuous increase, 'pride' posture was still higher than neutral from onset. This suggests that accessing conceptual knowledge about a negative emotion like disappointment leads to bodily changes that are observable in sitting posture, and distinct from neutral or positive affect. However, these findings are limited to oral word generation, and more research is necessary to extend this to auditory-heard or written information.

To return to posture used as a manipulation, rather than an end result, experimental manipulation of gait has also been reported to influence memory (Michalak, Rohde & Troje, 2015). Using biofeedback on a 'walking machine', gait was manipulated to resemble 'sad' or 'happy' walk. Participants were asked to encode self-referent descriptor words and later recall them. Overall memory showed a significance difference for gait conditions. The 'sad walk' resulted in equal numbers of negative and positive words recalled, while the 'happy walk' showed a positive bias, with significantly more 'happy words'. Similar patterns were confirmed in a sitting posture manipulation, where slumped posture resulting in a negative memory bias for participants with major depressive disorder, while open posture showed equal recall for negative and positive items. This suggests a positive bias for non-clinical samples and negative bias for mood disorders, but consistent with posture and not current mood. Importantly, these effects were presented even though participants were not informed of the expected interaction between gait and emotion, and even when mood was controlled for. This indicates that implicit semantic congruence between emotion in language and emotion in the body is sufficient to induce effects without conscious awareness.

In summary, the literature has investigated bidirectional relationships between bodily feedback and memory of emotional language. Most studies focus on autobiographical memory or self-referent words, which may increase emotion re-experience, but restricts the ecological validity and generalisability of these findings. It is unknown whether posture interactions occur only for events directly recalled from personal memory, or reveal more general overlap between language and body feedback through shared semantic representation of emotion.

4.2.4. Rationale

The literature on language and memory indicates several notable trends. First, verbal memory retained and manipulated over a short time period is conceptualised as verbal working memory, and shown to have links with semantic representation of long-term memory (Baddeley, 2012; Cameron et al. 2005). Second, this semantic access is expected to overlap with semantically represented physical experience. Sensorimotor and emotion experience are two of the most notable mechanisms through which physical information can support semantic understanding of words (Vigliocco, Meteyard, Andrews & Kousta, 2009), and this makes it an 'ideal candidate' for extending the role of embodiment to emotion comprehension in language. Third, evidence shows a bidirectional relationship between posture, gait/motion and memory of emotionally-laden information.

However, several aspects remain unclear. First, most research on emotion in verbal working memory considers broad effects of mood or emotion, and does not delve into the deeply cognitive processes proposed by embodiment research, where semantic representation, and not current state, guide the influence on comprehension. Conversely, research into posture and memory has explored embodiment, but only through the lens of autobiographic memory and self-referent language, simultaneously offering less experimental control over the resulting stimuli, and poorer generalisability to most language experienced in day-to-day life, which is not only self-referent in nature. The current study aims to extend these findings by combining methodologies from different strands of research.

4.3.5. Aims & Hypotheses

Following from Study 1, Study 2 aims to investigate recognition of negative, neutral and positive words under open and slumped sitting posture. The study will employ the materials reported in Chapters II and III, with the addition of a word recognition task designed specifically to test distinction of finer semantic details, beyond the valence recognition discussed in Study 1.

In consideration of results from Study 1, specifically posture effects with direction contradictory to expectation, the current study will refrain from directional hypotheses, and will focus on reaction time measures, as they demonstrated higher statistical sensitivity to the embodied effects discussed here (see Chapter III, Results). First, it is hypothesised that there will be differences in reaction time on positive items based on open versus closed posture. Second, posture will also have an effect on negative items. Third, no difference on neutral items is expected, as neutral language does not activate emotive information.

4.3. Method Study 2

4.3.1. Design

Similar to Study 1, the second experiment employed a 2.x3 repeated measures design to investigate whether postural conditions interfere with memory of emotional words. The first factor was posture, with two levels: open posture consistent with positive emotion, and slumped posture, associated with negative emotion. The second factor was valence, where language stimuli were grouped by emotion category – positive, negative and neutral. The dependent variables were accuracy and reaction time on a memory task, specifically recognition of valence words. An additional dependent variable of sentence reading times was used as an approximate measure of ease of comprehension.

4.3.2. Participants

The study used opportunity sampling to recruit a sample of volunteers. The recruitment method and exclusion criteria were consistent with those employed in Study 1 (Chapter III, section 3.3.2). The original sample included 40 participants. However, one participant was removed in accordance with the pre-registered exclusion criteria for accuracy and reaction time, and an additional volunteer was recruited. The resulting final sample consisted of 40 participants.

4.3.3. Materials and pilot testing

The study employed materials closely following from those of Study 1 (Chapter III, section 3.3.3.), in order to ensure consistency across experiments and allow Study 2 to build up on the conclusions of Study 1. This included 90 sentences developed for the valence recognition task in the first experiment: negative, neutral and positive sentences, created using the valence rating of words from the Warriner, Kuperman and Brysbaert (2013) database.

Study 2 introduced a memory aspect. After each sentence, a separate screen presented two words. The target word was present in the sentence just prior, while the distractor was a new, previously unseen stimulus. Importantly, both words belonged to the same valence category, i.e., both positive or both negative. Their valence was designed to be comparable, if not equivalent based on the Warriner et al. (2013) ratings. Thus, if the target word had a valence of 7.94, the distractor had valence of 7.90. The target and distractor were never from different categories, and always as close in valence as possible, while remaining syntactically plausible, i.e., adjectives or nouns. Arousal and dominance ratings were also considered, held constant at medium levels.

This was intended to prevent the task from being a simple recognition of valence, where participants recognise the correct word because it is the only one consistent with the valence of the sentence. While the task does not explicitly ask participants to be aware of the sentence valence, and is actually intended as an implicit task, it is assumed that the emotion content is processed. Thus, requiring participants to recognise the target word from a distractor within the same valence category would necessitate finer distinctions of semantic content and comprehension. As mentioned previously, the purpose of this study is to use memory as a measure of comprehension, where deeper processing of the emotion content is expected to result in better memory for the finer semantic differences between '*magical*' and '*relaxed*', even if both belong to the same valence.

The materials were pilot-tested using the protocols established in Chapter II. Ten participants performed the word recognition task under no postural conditions, resulting in average accuracy of 98% and average RT of 818.95ms. There was little variation between items regardless of emotion category, where most had 100% accuracy, 14 had 90%, and one had 80%. Reaction times on only two items were 2SDs above the mean. Problematic items were reviewed and alternative distractor words were chosen to resolve ambiguity, e.g., accidental semantic similarities with targets. The delay interval between sentence and memory probe, was originally set at 5secs. However, halfway through the pilot this was changed to 2secs, as participants reported impatience and reduced alertness. Accuracy and RT reported above are an average of the 2-second and 5-second versions, although the two showed very little variation, and in RT only. The 2-second window was used in the experiment.

Parallel to Study 1, a computer experiment programmed in OpenSesame was utilised to present items and collect responses. This was run on standard laptop devices using Windows 7 and Windows 10, where no other equipment was necessary. The study employed the demographic questionnaire described in Chapter III (see section 3.3.3), collecting information such as age, gender, education, as well as usual posture and preferred posture condition.

4.3.4. Procedure

The protocol utilised in this study was approved by the Health and Life Sciences Ethics Committee of Northumbria University in accordance with policies and legal regulations. Data processing and storage were consistent with the Data Protection Act (GDPR, 2018).

Participants were recruited via email adverts, the SONA system or in person on the Northumbria University campus. Recruitment and testing were performed by the main researcher in order to ensure consistency in how instructions were delivered. Participants were presented with an information sheet explaining that the study investigated the effect of posture on memory. Deception was used, as participants were not informed that different valence categories were employed, nor that posture was expected to interact with emotion. This deception was explained after the study. After signing a consent form (see electronic Appendices), participants completed the first half of the demographics questionnaire. Then they were given instructions about the task and a visual demonstration of the posture conditions.

Participants were given additional instructions in text at the start of the experimental paradigm. A short practice session of 12 items was used to familiarise participants with the task. The experiment was separated into two halves with a short, self-paced break in the middle. Each half was performed in a different postural condition in a counterbalanced order, and consisted of 45 sentences and the corresponding target/distractor words. A fixation dot was presented in the middle of the screen for 850ms before each item. Sentences were presented individually on the screen for 4000ms or until a button press. A blank screen was shown for 2000ms after the sentence. Then, the target/distractor word-pair were presented on either side of the screen, in counterbalanced order. Participants had to indicate which word was presented in the sentence before by pressing ‘Z’ or ‘M’ on the keyboard for ‘word on the left’ or ‘word on the right’, respectively. The words were presented until a button press or for a maximum of 4000 ms. Responses beyond this duration were classed as 'inaccurate'. The paradigm did not require the counterbalancing of left-right response keys necessary for Study 1 (see 3.3.4), as here the response did not correspond to valence judgment and is not expected to have emotion-space mappings.

At the end of the experiment participants were asked to complete the second half of the demographic form and indicate their usual posture, preferred posture and comfort level. Then, they were fully debriefed, including explanation of the deception and the role of body feedback in emotion, and thanked for participating.

4.4 Results Study 2

4.4.1. Treatment of data

The protocol for data processing and analysis was pre-registered on AsPredicted.org. This included procedures for applying cut-offs and removing items and participants.

First, reaction times over 4000ms were removed from the dataset, as this indicated that the stimuli had timed out, and were recorded as inaccurate response. Reaction times to inaccurate items were also removed. The experiment also collected reaction times (RT) on the sentence, i.e., when participants had indicated they had read the sentence. However, this data was removed for inaccurate items on the memory task, as it reflected participants had not fully understood or remembered the sentence even if they had read it within the time frame.

Second, exclusions were made on the participant level. Data on individual trials was removed if it were 2.5 SDs above the participant's mean RT. Participants were removed if less than 80% of their data remained after exclusions.

Lastly, exclusions on the sample level included accuracy below 90%. This reflected the high accuracy rates observed in Study 1 (Chapter III) and during materials validation (Chapter II). Participants were also excluded if their responses were 2.5 SDs below or above the mean for accuracy and reaction time, respectively. This referred to the overall sample mean after exclusion of RT for timeout and inaccurate items, but before participant means were applied and before exclusion of participants.

One participant was removed based on these criteria, and an additional volunteer was recruited to complement the sample to 40. This was in accordance with pre-registration.

There was one change from the pre-registered protocol, where the study was initially intended to collect 60 participants, but this was shortened to 40 due to recruitment issues.

4.4.2. Main analysis – accuracy of emotion memory

Descriptive statistics were run using IBM SPSS Statistics 22. Means for accuracy on the memory probe are presented in Table 10.

Table 10. Mean (SD) accuracy (%) for memory of negative, neutral and positive words under the open and slumped posture

N=40	Negative	Neutral	Positive
Open posture	98.50 (3.53)	98.95 (3.00)	98.50 (3.20)
Slumped posture	98.33 (3.29)	98.83 (2.98)	99.17 (3.09)

Consistent with Study 1 and with the confounds identified during material validation (see Chapter II), three Analyses of Variance were run to investigate negative, neutral and positive items separately. Bonferroni corrections for multiplicity of testing were applied, where significance level was set at .017.

A within-subjects ANOVA revealed no significant effect of posture on accuracy of memory on negative items, $F(1,39) = 0.06$, $p = .812$. Partial Eta squared indicated less than 1% of variance was explained by posture, $\eta p2$=.001.

The ANOVA revealed no significant effect of posture on neutral items, $F(1,39) = 0.04$, $p = .849$. Memory for neutral language did not differ based on open or slumped posture. Effect size confirms less than 1% of variance explained, $\eta p2$=.001.

The analysis of memory for positive words also revealed no significant difference between open and closed posture, $F(1,39) = 0.80$, $p =.378$. Posture accounted for 2% of variability in accuracy scores, $\eta p2$=.020.

In conclusion, the results on accuracy showed no effect of posture on memory of valence words. Overall, accuracy was at ceiling at 98-99%, which was higher than accuracy of valence judgments from Study 1.

4.4.3. Main analysis – reaction times of emotion memory

Means and standard deviations for RT on emotion words are presented in Table 11.

Table 11. Mean (SD) reaction times (ms) for emotion words under the open and slumped posture

N=40	Negative	Neutral	Positive
Open posture	887.86 (161.64)	839.24 (149.78)	834.76 (151.69)
Slumped posture	913.55 (190.95)	905.46 (201.78)	911.50 (196.99)

Within-subjects ANOVAs were conducted to investigate the effects of posture on reaction times. Negative items revealed no significant difference based on posture, $F(1,39) = 1.65$, $p = .206$. Four percent of variance were explained by posture, $\eta p2=.041$.

Results on neutral items also showed no significant difference, $F(1,39) = 4.65$, $p= .037$. While below the usual alpha criterion of .05, this did not meet the Bonferroni corrected level of .017. Partial Eta squared indicated that approximately 11% of variance were explained by posture, $\eta p2=.106$.

The analysis of positive words revealed a significant effect of posture on RT, $F(1.39) = 8.30$, $p=.006$. Reaction times under the open condition (M=834.76, SD=151.69) were significantly faster than performance in the slumped posture (M=911.50, SD=196.99). A medium effect size revealed that 18% of variance were explained by the condition, $\eta p2=.176$. Observed power was .80.

In conclusion, the analysis demonstrated that posture affected memory of positive words, but not negative or neutral. This revealed an effect based on congruence, where positive language was facilitated by open posture.

4.4.4. Exploratory analysis – two-factor analysis

Consistent with Study 1, a two-way analysis was used to confirm the interaction between posture and valence, as well as explore the main effects of posture and valence. This was important to ensure that the effects of posture were based on congruence only, and not a main effect, and to follow up on the difference between negative and positive items consistently found across validation and Study 1 (see Chapter III).

4.4.4.a. Two-factor analysis of accuracy on word recognition

A two-factor within-subjects ANOVA was run. Mauchley's Test of Sphericity indicated no issues on valence, Mauchly's W = .960, $\chi2$ (2) = 1.54, $p = .462$, nor the interaction of valence and posture, Mauchly's W = .949, $\chi2$ (2) = 1.98, $p = .372$. Thus, sphericity was assumed.

The analysis revealed no significant effect of posture, F(1,39) = 0.07, *p* =.800, *ηp2* =.002. Valence also showed no significant differences in accuracy, F(2,78) = 0.54, *p* =.583, *ηp2* =.014. There was no significant interaction, F(2,78) = 0.64, *p* =.532, *ηp2* =.016. This is consistent with the main analyses and additionally shows no main effect of valence on accuracy.

4.4.4.b. Two-factor analysis on reaction time of word recognition

Mauchley's Test of Sphericity indicated the assumptions of sphericity were not violated for valence, Mauchly's W = .915, χ2 (2) = 3.36, *p* = .186, nor the interaction of valence and posture, Mauchly's W = .965, χ2 (2) = 1.36, *p* = .508. Sphericity was assumed.

The analysis revealed a main effect of posture, F(1.39) = 5.25, *p* = .027, with a small effect size, *ηp2*=.119. Estimated power was at .61. Means indicate that performance under the open posture condition (M=850.62, SD=23.54) was significantly faster than the slumped condition (M=910.17, SD=30.03).

A main difference on valence was also found, F(2,78) = 5.76, *p* = .005, where 13% of variance were explained by valence, *ηp2*=.129. High power levels were indicated at .86. Post-hoc analyses show that reaction time on negative items was significantly different from neutral, t(39) = 2.77, *p* =.025, and positive items, t(39) = 3.43, *p* =.004. Neutral items did not significantly differ from positive, t(39) = 0.09, *p* =1. This indicates that reaction time was slower for negative items (M=895.70, SD=24.28) compared to both neutral (M=872.35, SD=23.52) and positive (M=873.17, SD=24.40), while neutral and positive had comparable performance.

The main analysis found no significant interaction of valence and posture, F(2,78) = 2.29, *p* = .108. Thus, this will be further explored in Figure 5.

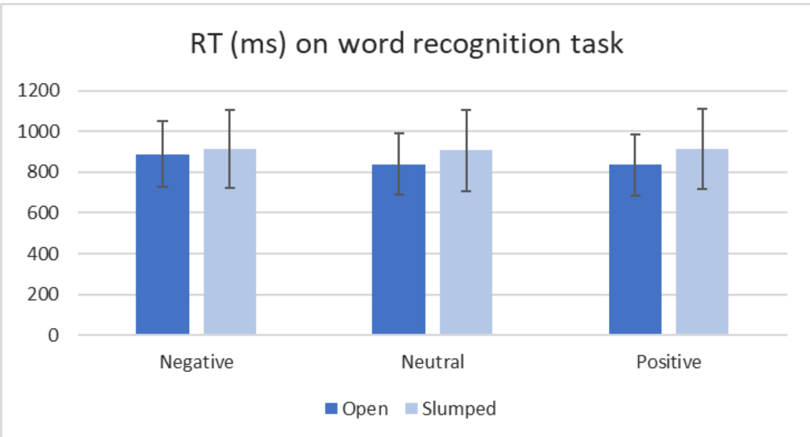

Figure 5. Reaction time (ms) on negative, neutral and positive items under open and slumped posture

4.4.5. Exploratory analyses – Two-factor analysis of responses to sentences

Another exploratory variable included in the study was responses to the sentences only. This measure indicated whether participants had read and understood the sentence. An 'inaccurate' response meant that participants did not press a key before the presentation window of 4000ms ran out. As such, 'accuracy' was considered a nonsensical measure and was not reported here. However, reaction time to sentences could indicate that some items were processed more easily than others. Ceiling accuracy on word recognition suggested that reading sentences faster than the maximum duration did not impair performance, and thus this was considered a suitable measure of comprehension. The two-factor analysis of posture, valence and their interaction on sentence RT is reported below.

4.4.5.a. Reaction time to sentence comprehension

Means and standard deviations of sentence RT are reported in Table 12.

Table 12. Mean (SD) for RT in ms on sentence comprehension

N=40	Negative	Neutral	Positive
Open posture	1519.41 (524.68)	1425.86 (453.70)	1465.67 (479.88)
Slumped posture	1564.79 (559.09)	1431.17 (482.50)	1532.13 (504.17)

A within-subject ANOVA was run to explore the effects of posture, valence and their interaction on sentence reading times. Mauchley's Test of Sphericity indicated no problems with specificity for the valence, Mauchly's W = .959, $\chi 2$ (2) = 1.59, *p* = .451, and the posture-valence interaction, Mauchly's W = .915, $\chi 2$ (2) = 3.37, *p* = .158. Results for sphericity assumed were reported.

The analysis reported no significant effect of posture on sentence RT, F(1,49) = 1.14, *p* = .291, *ηp2*=.028. This indicates that any overall differences between open and slumped posture did not affect performance.

However, a significant main effect of valence was found, F (2,78) = 20.04, p < .001. A medium-to-large effect size indicates that 34% of variance in reaction times were accounted for by emotion category, *ηp2*=.339. Observed power was indicated at 1. Post-hoc pairwise comparisons using Bonferroni method indicate that RT on negative items was significantly different from neutral, t(39) = 5.86, *p*< .001, but not positive sentences, t(39) = 2.33, *p* =.076. Positive items (M=1428.52, SD=71.44) were significantly faster neutral items (M=1498.90, SD=75.60), t(39) = 4.33, *p*<.001.

There was no significant interaction of posture and valence, F(2,78) = 2.68, p = .075, $\eta p2$=.064. Figure 6 displays the results.

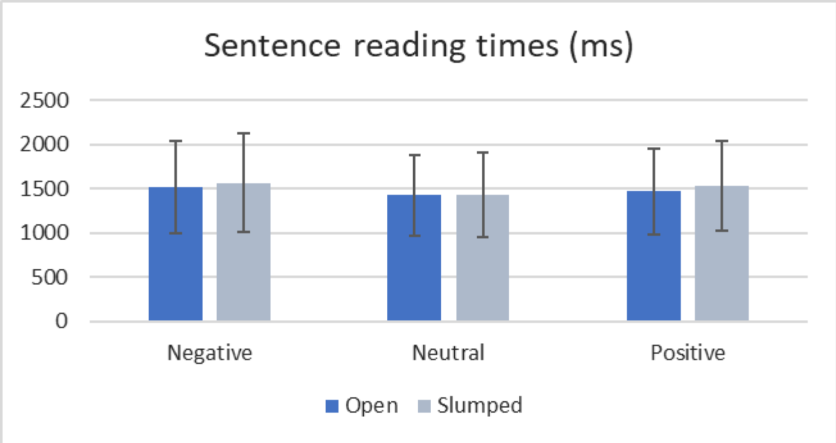

Figure 6. Sentence reading times (ms) for negative, neutral and positive sentences under the open and slumped posture

4.4.6. Conclusion of results

Overall, the results from Study 2 indicate no effect of posture on accuracy of verbal memory, regardless of emotion category. For reaction time, no effects were found for negative or neutral items, but a significant facilitatory effect was reported for positive items. Exploratory results confirm the main effects of valence found in Study 1, extending this to word recognition and sentence reading times.

While only one notable interplay between posture and emotion category was found, reaction time of positive words, this demonstrated a moderate effect size and high power. This demonstrates that, while the embodiment of emotional language is limited to specific circumstances, the observed effects have a meaningful role in reaction time performance. Effects on accuracy may be difficult to observe and detect statistically, and performance is at ceiling. The implications of these findings are discussed in the next section.

4.5. Discussion of Study 2

4.5.1. Summary of findings and hypotheses

Study 2 aimed to investigate the interaction of posture and emotion as measured in memory of emotional words. Specifically, the measurements were designed to engage deeper comprehension of emotional content and distinction of finer semantic meaning from memory (see 4.2. Introduction). Accuracy and reaction time are discussed separately, as they demonstrate distinct, even if overlapping aspects of performance.

Main results indicated no effects of posture on accuracy, irrespective of valence category. Reaction time demonstrated the differential patterns observed in Study 1, with no effects on negative or neutral items, but a significant difference between open and slumped posture for positive items only. However, contrary to Study 1, the current results found that congruent posture facilitated performance, i.e., open posture resulted in faster RTs on positive language. This could be attributed to the different measures explored by the two experiments, namely valence recognition versus memory for individual words. Further, the process investigated in Study 1 was explicit and required conscious awareness of the emotive content, while participants in Study 2 were not informed that the materials were related to emotion and thus the experiment measured an implicit process.

The results support Hypothesis 1, showing differences in reaction times of positive sentences. However, results do not support Hypotheses 2, which expected different performance on negative sentences as well. Hypotheses 3 was supported, as no significant differences on neutral items were found.

Beyond the hypothesised differences, exploratory analyses confirm the main effect of valence consistently found across this project, with differences between negative and positive items. Study 2 also reports unexpected main effects of posture, with slumped posture resulting in slower performance. This will be discussed as a potential limitation later. Exploratory analyses of sentence RT also demonstrate a confounding effect of valence with negative items processed more slowly than positive. This contradicts the findings of Study 1, where negative sentences were processed fastest and demonstrated the highest accuracy (see Chapter III). This pattern potentially reflects the different demands of a memory task and corresponding change in participants' strategies.

4.5.2. Interpretation

Similar to Study 1, the current results partially support the proposed embodiment effects, where physical information of the body is expected to facilitate processing of the corresponding valence in language stimuli. According to the principles of classical embodiment (Barsalou, 2008a, 2008b), congruent information from the body can support understanding of abstract concepts, even in language. The current findings demonstrate such a facilitatory effect, however restricted to positive items only. While this is consistent with previous results from this project, it suggests that embodiment in emotional language is either partial, or unsuccessful except in highly specific circumstances (see Chapter VI).

The ceiling accuracy of word recognition suggests that sentences were an effective method for investigating verbal memory. This supports previous literature on chunking, where information is more easily retained when grouped compared to single-item presentation (Haj et al. 2020; Huntley et al., 2011, Thalmann et al. 2019) and particularly strong for sentences (Baddeley et al., 2009). This utilisation of organisation and semantics is consistent with most models of working memory, including Baddeley (2000, 2012) and Logie (Logie & Logie, 1995; Logie, 2011). One point of caution when interpreting these findings is that the aforementioned models acknowledge the role of semantic memory, but do not fully discuss how that occurs, nor focus in-depth on the nature of this semantic content. The current study aims to explore precisely this rich semantic access, and may be more appropriately discussed in terms of embodiment models or data on semantic representation, such as Vigliocco and Vinson (2007) and Vigliocco, Meteyard, Andrews, and Kousta (2009).

Study 2 is consistent with memory research that discusses semantic information as accessed through long-term memory (Cameron et al. 2005; Klimesch, 1994). Results can be interpreted in relation to the role of partially activated long-term memory in the Cowan (1995) model of WM. This model specifies a very narrow scope of focused attention, capable of holding 3-4 phonological or verbal items. The current results show memory at ceiling even with seven-word sentences, suggesting that the entire sentence may be ‘chunked’ as one item, as discussed by Norris, Kalm and Hall (2019). Thus, the current results support chunking as an effective method for holding longer stimuli in active memory. High performance could be attributable to the strong conceptual links between emotional information and body feedback, this time acting to support long-term memory links and provide an organisational strategy that compensates for the excessive attentional load. Overall, as the paradigm of Study 2 was designed to reflect semantic comprehension tasks more than classical WM experiments, the findings should be interpreted in relation to WM models with some caution.

The differential effects for accuracy and reaction time are consistent with previous research. Even in clinical populations with motor cortex damage, accuracy on word tasks is relatively intact, compared to impairments in RT (Kemmerer, Miller, MacPherson, Huber & Tranel, 2013). This suggests that reaction time may be more sensitive to variability in performance, in particular when accuracy is at ceiling, and thus suitable for exploring small-to-medium effect sizes where statistical power and the sensitivity of analysis play an important role. It is not surprising that accuracy revealed no effect when performance was at ceiling for all valence categories, ranging 98-99%. This most likely reduced variability on accuracy to an extent where it becomes a non-sensical measure.

Perhaps most importantly, the current results present some support for previous research on emotion memory and embodiment. Similar to the findings of Michalak et al (2014, 2015), posture manipulation facilitated memory of congruent items. Most previous research in this area uses active motor movements, e.g., walking (Michalak et al, 2015) or sit-to-walk movement (Kang & Gross, 2015), which involve similar body clusters to the posture manipulations used in this study, such as slumping and lowered head, but also incorporate an active component.

Motion is strongly associated with up-down mappings of emotion, where ‘up’ correlates with positive valence and ‘down’ with negative. Casasantro and Dijkstra (2010) demonstrate that participants recall more positive events after performing upward arm motion, with comparable results for negative items. Dudschig, de la Vega and Kaup (2015) confirms this vertical association. However, they also suggest that the space-emotion mapping is dependent on posture. While valenced words without a motor component did not activate the vertical space mapping, words with strong associations to posture interact with space, for example ‘*proud*’ with expansive posture and ‘*sad*’ with slumped. The direction of motion associated with ‘happy’ and ‘sad’ information is consistent with the currently reported passive posture condition, as the vertical element is present in the ‘slumping’ and ‘openness’ that characterise these postures. Thus, the current results can be interpreted in relation to previous research on body motion and its affective correlates, although the role of active versus static body feedback is yet to be fully explored.

4.5.3. Strengths and limitations

Study 2 accomplishes several important steps toward understanding the role of embodiment in processing emotive content. First, the study extends previous findings on valence recognition to a different cognitive process – memory. While valence recognition measures explicit awareness and comprehension of emotional information, difference between sentences based on valence only are more obvious and arguably more shallow than finer semantic meanings. The current study addressed that by utilising target and distractor words with comparable or equal valence ratings, and thus preventing surface processing of valence categorisation only. Instead, participants needed to access the semantic representation of the sentence and target/distractor word and identify which of two otherwise comparable items is *best* suited within the sentence. This requires deeper semantic access compared to Study

1. Arguably, participants may have performed the task simply using memory processes. However, it is argued that long chunks of information are organised into patterns and utilise semantic representation (Baddeley, 2012, Logie, 2011), which once again involves activating contextual information from memory and is thus consistent with embodiment.

Second, the study extended previous findings on affective memory beyond the self-referent or autobiographic memory discussed by previous research. This improves the ecological validity of the study, and also shows that working memory, as well as autobiographical memory, can demonstrate embodiment effects. The study continued to develop and improve the methodology identified in Chapters II and III, building toward a standardised set of valenced language stimuli for embodiment and memory research alike.

However, some limitations need to be considered. The current project may have failed to account for parts of the cognitive process underpinning working memory in language. As previously mentioned, the study does not fully fit within popular models of working memory. The role of attentional resources and executive control, highlighted as key by Cowan (2008), is unknown for the current results. Research has consistently reported that executive function is necessary for visuospatial working memory performance, even when such central processes are not explicitly intended in the task (Allen, Baddeley & Hitch, 2017; Hamilton, Coates & Heffernan, 2003). Attentional resources also interfere with access to verbal semantics during visuospatial tasks (Brown & Wesley, 2013). This could suggest that semantics on verbal tasks are also inhibited, although theoretical models discuss attention in the context of visual memory more than verbal, and disagree whether access to semantics is achieved through central resources (Logie, 2011) or directly to verbal processing centres (Baddeley, 2012). While the current project did not aim to explore the role of executive function, attention may be necessary for accessing semantics during memory tasks. It is unclear whether attentional resources are involved in the specific semantic processes proposed in this project, and thus whether attentional load needs to be accounted for. Future research aiming to confirm the results reported here should consider using tasks with low demands on attention or investigating the association between executive function and verbal semantics further.

Additionally, the main effects of valence and posture found on some measures are not consistent with the purpose of the project, and may confound the assessment of embodiment by masking or falsely inflating interaction effects. The overarching difference between negative, positive and neutral language appears ever-present in valence recognition (Chapter III) and verbal memory (Chapter IV), including when no postural manipulation is present (Chapter II. Material development and validation). The current study attempted to control for this influence on an ‘as good as possible’ principle by investigating the three valence categories separately and making differential hypotheses. However, this did not account for the main effect of posture on reaction time found it this experiment. As this was inconsistent with results from Study 1, it may be premature to interpret it as posture interfering with verbal processes overall, and the proposed effects strictly dependent on congruence are still a more plausible explanation.

In summary, body posture is found to influence memory of positive, but not negative or neutral words. Future research is also necessary to explore how this pattern for short linguistic items such as sentences and words fits within more naturalistic examples of language, such as texts. Chapter V will discuss this next.

5. Chapter V. Study III: Body posture and memory of affective information from text: an embodied perspective

5.1. Overview of Study 3

Chapter V will re-contextualise affective language with a focus on longer text and narrative, and highlight the cognitive differences in processing longer formats. The experiment detailed here will aim to explore memory of affective information from text, as an indicator of semantic understanding, and compare the effects of open and slumped posture on positive language in particular. While the Design and Procedure closely reflect those of Study 1 and 2, the Method will detail how language materials were adapted and validated.

Contrary to previous experiments, results indicate no significant effects of posture on positive items, and no main effects of posture or valence. This contradicts embodiment literature, as well as the previously observed consistent differences between positive and negative language. However, this contradiction is discussed as the possible result of linguistic confounds, such as imagery, metaphoricity and high abstract loadings, and not evidence against embodiment. Implications for future research are discussed, including further development and validation of texts that consider ratings for concreteness, imagery and other confounds which may be used for semantic facilitation beyond the internal bodily feedback explored by this study.

5.2. Introduction Study 3

Experiment 1 and 2 of this project have established that the embodiment of emotion is possible, albeit in specific circumstances, and can be observed in language. Previous research has extensively rated individual words for valence and other affective properties (Bradley & Lang, 1999; Grühn, 2016; Warriner, Kuperman & Brysbaert, 2013) and explored interactions between emotion and spatial mappings, i.e., forward and backward (Markman & Brendl, 2005; Van Dantzig, Zeelenberg & Pecher, 2009). However, sentences and texts have received less focus. While comprehension and memory of text has been investigated in relation to other physical properties, i.e., imageability (Sadoski, Goetz & Fritz, 1993b) and concreteness (Sadoski, Goetz & Rodriguez, 2000), less is known about affective properties and especially how they are embodied.

A few seminal studies have demonstrated embodiment in sentences. Glenberg, Havas, Becker and Rinck (2005) observe that positive and negative sentences are processed differently based on facial feedback. Havas, Glenberg and Rinck (2007) confirm this, with 'smiling' condition facilitating positive information, and 'frowning' priming negative sentences. This demonstrates muscle feedback from faces is utilised for comprehension.

Nummenmaa, Glerean, Hari, and Hietanen (2014) use vignettes to elicit several distinct emotions and observe heat maps of corresponding full body activations. Results indicate somewhat consistent high activations in the upper body and head region across positive emotions, such as joy, pride, love and contentedness. In contrast, negative emotions, such as sadness and shame, display far weaker activation. This can be interpreted in relation to the approach/avoidance hypothesis of emotion, where positive affect is forward oriented and prepares for action, while negative affect, with the exception of anger, is characterised by withdrawal from environmental stimuli. Kang and Gross (2015) further observe that motion, specifically the act of rising from a sitting position, is influenced by describing emotion in words. When participants are asked to recall positive, negative and neutral events from personal experience, their consequent motion displays higher velocity, range of movement and upward head position after positive memories compared to negative or neutral.

Overall, more is known about autobiographical memory of affect, and of body-language interactions from sentences and other short formats. This is consistent with the expansion/constriction dimension employed in the current project. However, it is difficult to interpret these results as evidence for the embodiment of language that is not self-referent, as well as longer texts.

5.2.2. The nature of text – comprehension, memory and beyond

Perspectives on text comprehension encompass purely linguistic processing, memory and situational models (Zwaan & Singer, 2003). Research tends to focus on factors that facilitate learning from text, for example for educational purposes, and identify that topical knowledge and text coherence improve learning (Kintsch, 1994). On a neural level, text comprehension is consistent with fronto-temporal cognitive models of working memory and theory of mind (Mar, 2004). However, there is also evidence for the role of semantics. Text comprehension involves processing words and sentences, but also inferences and expectations that combine the reader's knowledge of the text with knowledge of the real world (Balota, d'Arcais & Rayner, 1990).

Different perspectives range in the importance attributed to semantics, compared to other linguistic properties such as morphology or grammar (McNamara & Magliano, 2009) Some models conceptualise comprehension of text as a series of coherent semantic representations that explain the narrative – the reader attempts to discern meaning and thus attribute events to causation (Graesser, Singer & Trabasso, 1994). Tierney and Pearson (1983) describe reading as an act of composing – inferring meaning, gauging intentions of the author and one's own interpretation, where the reader is an active agent. Semantic cues and, importantly, the reader's experience are both tools used to achieve comprehension. This culminates in the Mental Models theory, which states that reading texts involves building mental representations which are somewhat independent from linguistic properties (Garnham & Oakhill, 1996). Mental models contain what the text means – characters, events, objects, where recognition and reaction time reflect understanding of event sequence, and not text structure (Glenberg, Meyer & Lindem, 1987). Moreover, information relevant to the protagonist's actions within a narrative is processed even when implicit (Morrow, Bower & Greenspan, 1989). Thus, comprehension of text is semantic in nature and action-oriented, where understanding of mental states, events and accompanying relevant information is accessed.

Emotion is another source of information used to facilitate understanding of narrative. Inferences of the character's affective states, as well as the reader's own emotions, are accessed during story reading (Dijkstra, Zwaan, Graesser & Magliano, 1995). Processing literary text can be conceptualised as a combination of cognitive and emotive factors (Kneepkens & Zwaan, 1995), and even defined by empathy (Keen, 2006, 2007). Miall (2006) argues that emotive content may be one of the distinguishing features of literary text, where aesthetic appreciation is built from pleasurable response to affective content, empathy with characters and even the interaction between emotion and action, i.e., feeling as a motivator and a driving agent. Emotive response in the reader, as well as linking emotion to action within the narrative, is arguably the product of mental models (Oatley, 1995), similar to other semantic representations.

Evidence suggests that emotion category is accessed on the word level and narrative level, and performance is inhibited when implied and explicit affective cues are incongruent (Soederberg & Stine, 1995). Reaction times are also slower when responding to an affective sentence whose valence clashes with that of previous parts of the text (Vega, 1996), as that requires updating and shifting mental models. This further exemplifies the need for research materials that are planned with attention to individual words, as well as the overall story, and include consistent valence throughout, i.e., positive text should not include negative sentences or words. The material development procedure discussed in Chapter II and III can account for this interplay.

In summary, text comprehension involves the semantic and affective processes discussed in previous chapters. However, mental models theory suggests that text is not a collection of sentences, but rather integrative in nature (Garnham & Oakhill, 1996), where the resulting representation is not equal to the sum of its parts. Further, Miall and Kuiken (2001) discuss perspective shifts on the text level that build more complex understanding, and are not possible on the sentence level. This implies that the cognitive processes for semantic access and meaning representation observed in sentences may not be the same for longer formats.

Thus, it is interesting to observe whether semantic facilitations proposed by situational and embodied models of cognition hold true to text comprehension, as well as words and sentences. Arguably, text has higher ecological validity, as it is more representative of daily language processing, such as reading the newspaper, or filing reports to work, or enjoying a good novel. Exploring text can answer the age-old debate – to what extent cognitive models are applicable to real-life language understanding.

5.2.3. Rationale, aims and hypotheses

The current project established that embodied manipulation from posture can interact with comprehension of affective information (Chapter III) and extended this to memory from sentences (Chapter IV). The next step in exploring the embodiment of posture is employing full text, as this format introduces a more complex semantic environment, where narrative requires cohesion, i.e., a topic maintained throughout, and builds semantic content from a wide range of affective words.

Study 3 aims to develop several texts with positive, negative and neutral valence, validate them through a piloting procedure reflective of the one reported in Chapter II, and investigate them under experimentally induced postural conditions. Memory of details from text would be measured with a target/distractor task similar to Study 3. Previous research has demonstrated that word recognition is particularly receptive to implicit, as well as explicit understanding of text (Haenggi & Perfetti, 1994). It is hypothesises that reaction time on word recognition, as a measure of implicit affective judgment, would differ between open and slumped posture for positive and negative language, but not neutral.

5.3. Method Study 3

5.3.1. Design

Consistent with Study 1 and Study 2, a 2x3 repeated measures design was used to observe the interaction between posture and valence of English texts. Factor 1 was posture with two levels – open and slumped. Factor 2 was valence, with three levels – negative, neutral and positive. The dependent variables were accuracy and reaction time on memory from text, specifically a word recognition task.

5.3.2. Participants

The study used the same recruitment principles and exclusion criteria applied in Study 1 and Study 2. For a detailed summary, see Chapter III. A sample of 40 volunteers was recruited. Similar to Study 2, the experiment originally intended to recruit 60 participants, which was lowered to 40 after issues with recruitment. The sample consisted of 18 males and 22 females with a mean age of 25.55 (SD=7.98). Minimum age was 18 and maximum – 50. The sample included 31 Native English speakers, eight participants with non-English native language and one bilingual. Analysis of proficiency confirms that 35 participants were fully fluent in English, with four participants with working proficiency and one with functional. Working proficiency referred to fluency sufficient for daily life and work, while the term 'functional proficiency' was used to refer to only basic English skills.

Education levels varied, with six participants with A levels, 15 with 'some university', i.e., currently studying, 10 with a Bachelor's degree, eight with Master's level and one with a doctorate. There were no participants with reported physical disabilities. Three participants with self-reported dyslexia were included in the final sample. Participants were not removed based on language disabilities, as the treatment of data before analysis employed very strict criteria for both accuracy and reaction time alike. Participants with reaction time substantially slower than the average were removed during data processing, and individual items with RT outside of the participant's own average were not be included in the analysis. These measures can reduce any additional variability introduced by learning disabilities.

5.3.3. Materials

The study designed new language materials using the principles identified in Chapter II . This included six narrative texts, approximately three paragraphs long. Two paragraphs per valence were developed. Consistent with Study 1, each text was built from individual words taken from the Warriner, Kuperman and Brysbaert (2013) database. A positive text included positive and neutral words only, while a negative text – negative and neutral. Neutral texts included neutral items only. Development of text with positive-only or negative-only items was found to be practically impossible, as many functional verbs, such as 'go' and 'walk', as well as many nouns, were neutral in valence. Average valence ratings per text were based on every word, excluding a small proportion of words which were absent from the database. Determinations of valence followed the cut-offs identified in Chapter II. Importantly, items were also controlled for arousal and dominance, where medium levels were used across valence. On average the texts contained 951 syllables and 2818 letters.

Unlike previous experiments, the sentences used to compose these texts were not equal of length. This was intended to improve ecological validity and reflect real-world textual formats, including some simulated variability. Naturalistic text from blogs has been used successfully for valence recognition (Aman & Szpakowicz, 2007), demonstrating the suitability of this method. Short excerpts are shown below (full materials in Appendices).

Positive:

'*This summer John and Mary went on a special holiday. They were a young couple on their first adventure. They had just gotten married and they were excited and optimistic. This was their honeymoon and they wanted it to be perfect.*'

Neutral:

'*It was a busy day for Robert. He had to do chores and go to work in the office. He brushed his teeth, made toast and sat down to read the news. It was his morning ritual and an important part of his daily routine.*'

Negative:

'*It was a dismal and gloomy morning. The graveyard was abandoned and lonely, with broken headstones scattered around the ruins of and old crypt. In the darkened gloom, a widow limped toward a lonesome grave. The widow slumped over the cracked tombstone, tears falling*.'

The memory task included eight questions per text. Questions probed memory of specific events within the narrative, for example '*John and Mary had just celebrated their...*' Following from Study 2, responses included word recognition from two options. In the example above, the correct response was '*marriage*', and the distractor – '*success*'. Targets and distractors were matched for valence, i.e., both positive or both negative.

The materials were pilot-tested with a sample of seven participants. This resulted in 91% average accuracy and 1432ms average reaction time. Positive texts had accuracy of 84% and 96% and RT around 1500ms. Both neutral texts revealed 95% accuracy, RT between 1252 and 1375ms. Accuracy on negative texts was 95% and 86% respectively, RT between 1350 and 1522ms.

5.3.4. Procedure

The study received ethical approval by the Health and Life Sciences Ethics Committee at Northumbria University. Ethics documents, e.g., Information sheets, and recruitment adverts are included in Appendices.

Participants were recruited via opportunity sampling, brought to the lab and explained what the study would entail. After signing informed consent, participants completed part of the demographic questionnaire and received written instructions about the postures. Then they proceeded to the practice session of the experiment, which included one neutral text with eight corresponding questions.

Posture conditions were started after the practice session, and counterbalanced across the two halves of the experiment. Each half contained one text per valence category. Valence was pseudo-randomised. In the firs half, the order was positive-neutral-negative; second half – negative, neutral, positive. Neutral narratives were placed between more emotive texts as an impromptu 'buffer', to prevent a sudden change from highly positive to highly negative information. Participants were allowed to read the texts at their own speed, and were informed they would be asked questions about them. When ready, participants pressed 'space' to continue. Reading speeds were collected. Then, a question was presented individually on the screen for 4000ms or until a keypress. The answers were presented after a 350ms fixation dot. This was employed to prevent reading speed of the sentence from interfering with reaction time to the memory probe. The target and distractor were presented on either side of the screen (Figure 7) for a maximum of 4000ms or until keypress, and this reflected reaction time on the memory task.

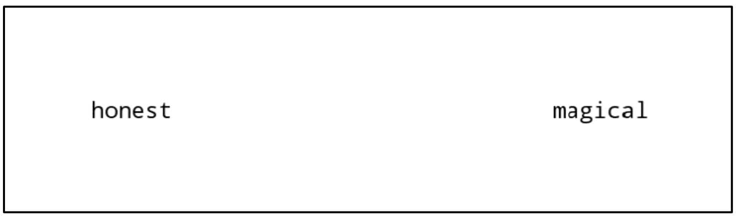

Figure 7. Example memory probe, target and distractor from positive valence, text Pos1

5.4. Results: Study 3

5.4.1. Treatment of data

In accordance with pre-registration (Appendix A), cut-offs were applied on the item, participant and sample level. Reaction times on inaccurate items were removed. Timeout responses (longer than 4000ms) were considered inaccurate. Data points on the participant level were removed when 2.5 SD above the participant mean. Participants would be removed if less than 80% of items remained. On the sample level, participants were removed if 2.5 SDs below the sample accuracy, and 2.5 SDs above sample RT. No participants were removed at this stage.

The pre-registered criteria included absolute cut-offs for accuracy at 80%. However, this was based on results from the original pilot, Study 1 and Study 2, all of which used sentences and not text. Accuracy on Study 3 had more variation than expected. Two participants who were found to be just below absolute cut-off, at 77%, but above the sample cut-off of 75%, were retained in the sample.

Reading times for the full text were collected. However, reading was self-paced and varied greatly between participants and between texts, including some anecdotal suggestions of re-reading for enjoyment. While this meant participants engaged with the task, it was considered reflective of many different processes beyond comprehension, and thus not suitable for analysis.

5.4.1. Main analysis – reaction time

Reaction time was identified as the main focus of analysis. Descriptives demonstrate RT for negative, neutral and positive items under the open and slumped postural conditions.

Table 13. Mean (SDs) reaction times on memory of negative, neutral and positive text

N=40	Negative	Neutral	Positive
Open posture	1292.93 (288.90)	1280.29 (348.00)	1336.80 (384.82)
Slumped posture	1351.37 (316.42)	1344.13 (368.74)	1290.90 (296.01)

Per pre-registration, three Analyses of Variance were performed to investigate valence categories separately. There was no effect of posture on negative items, $F(1,39) = 3.43$, $p = .072$, $\eta p2 = .081$. Neutral items also did not differ based on posture, $F(1,39) = 2.33$, $p = .135$, $\eta p2 = .056$. No differences were found for positive language either, $F(1,39) = 1.28$, $p = .265$,

$\eta p2$=.032. This suggests that open and slumped posture had no differential associations with valence, and neither influenced reaction time on memory from text.

5.4.2. Exploratory analyses

In accordance with pre-registration, two-factor analyses of accuracy and reaction time were conducted to explore the previously found main effects of valence and posture.

5.4.2.a. Two-factor analysis of accuracy

A within-subject ANOVA was conducted. Mauchley's Test of Sphericity suggested problematic values for valence, Mauchly's W = .744, $\chi 2$ (2) = 11.23, p = .004. Thus, results using Greenhouse-Geyser corrections are reported. The posture-valence interaction did not display issues with sphericity, Mauchly's W = .915, $\chi 2$ (2) = 3.38, p = .185.

Analysis revealed no significant effect of posture on accuracy of text memory, F(1,39) = .10, p =.753, $\eta p2$=.003. A main effect of valence was found, F(2.78) = 5.04, p =.015, $\eta p2$=.115. Post-hoc analysis showed that memory of negative information (M=.89, SD=.01) was significantly different from positive (M=94, SD=.01), t(39) = 4.09, p < .001, but not neutral M=91, SD=.02), t(39) = .69, p = .489. Neutral items did not significantly differ from positive, t(39) = 2.00, p = .056. Overall, negative items had the lowest accuracy and positive – highest.

The main ANOVA found no significant interaction between posture and valence, F(2,78) =1.18, p = .313, $\eta p2$ = .029, which suggests no embodiment effects on memory accuracy.

5.4.2.b. Two-factor analysis on RT

Mauchley's Test of Sphericity suggested no issues with valence, Mauchly's W = .967, $\chi 2$ (2) = 1.28, p = .528, or the interaction, Mauchly's W = .959, $\chi 2$ (2) = 1.59, p = .451.

The ANOVA demonstrated no main effect of posture, F(1,39) = 1.32, p = .258, $\eta p2$ = .033, nor valence, F(2,78) = .06, p = .944, $\eta p2$ = .001. No interaction was found, F(2.78) = 2.63, p = .079, $\eta p2$=.063. This confirms the results from main analysis, and interestingly shows no overall difference between emotion categories, contrary to Study 1 and 2.

5.4.3. Conclusions

Results from Study 3 show no interaction between posture and valence on accuracy and reaction time of verbal memory. Curiously, valence had a main effect on accuracy, but not reaction time, where negative words from text were remembered more poorly than positive.

5.5. Discussion Study 3

5.5.1. Summary and interpretation of findings

Study 3 aimed to explore embodiment of emotion as seen in memory of valenced words from text. Results found no evidence for an embodied effect on memory of negative, neutral and positive language. Word recognition did not differ between open and slumped posture regardless of valence category. Contrary to Study 1, accuracy on negative items was significantly poorer than positive. This somewhat follows results from Study 2, where neutral items had poorer reaction time.

These results do not support the hypothesis, namely that posture would interfere with positive items. No predictions were made concerning neutral and negative language. Exploratory analyses also reveal partial and somewhat contradictory effects of valence, which is consistently present across studies in this project, but with unpredictable direction.

Results from Study 3 appear to contradict what we know about posture and valence. Presumably, longer exposure to postural manipulation during text reading would enhance embodied effects. At first glance, current results contradict the assumptions of embodiment (Barsalou, 2008a, 2008b), and observe no facilitation effect when the physical semantics of posture, i.e., ‘approach’ and ‘withdrawal’, interact with the verbal semantics of positive and negative emotion. As affective content is accessed during text comprehension ((Dijkstra, Zwaan, Graesser & Magliano, 1995), and even sensitive to emotion on the word (Soederberg & Stine, 1995) and sentence level (Vega, 1996), absence of embodied effect suggests that cognitive understanding was not primed by congruent physical states, or, conversely, a mismatch between the specific emotive content of the texts and the approach/withdrawal bodily feedback used in the present study.

In this light it is worth considering that previous research reporting embodiment of emotion investigates facial feedback (Glenberg, Havas, Becker & Rinck, 2005), rather than full-body mechanics, and uses sentences or short vignettes (Havas, Glenberg & Rinck, 2007). Further, such materials were self-referent in nature, i.e., a scenario where the reader imagines actions, situations and feelings associated with a particular valence, such as ‘*You are receiving an award from your accomplishments*’. Research on body associations and language also uses personal information, such as writing down a personal emotive memory (Kang & Gross, 2015), autobiographical memory (Casasantro & Dijkstra, 2010; Riskind, 1983) or responding to affective words referring to oneself (Michalak, Rohde & Troje, 2015). This does not reflect the same processes as comprehension of a storyline that does not involve the self. Arguably, previous literature involves involve monitoring of one's own emotional response or awareness of past experienced effect, and not comprehension of what emotion is, as a whole. This, and the use of longer narrative, may explain why current results differ from the consensus of embodied emotion literature, and may suggest that embodiment is sensitive to personal experience, where comprehension is improved only when supported with personal relevance. As such, the semantic representation of physical response to emotion might be '*what happiness means to me'*, and not '*what happiness means in general*'.

Cognitive understanding of text is notably different from the previously explored sentences and vignettes, including differences in how semantic information is accessed. Burke (2010) suggests that reading affective literary text activates personal memory of emotion. However, that may also cue associations and memories beyond affect. Semantic content and any consequent mental representations is not restricted to one source only. Mental models of text comprehension involve visualisation (Mayr, Schreder, Smuc & Windhager, 2016), and imagery is used to represent and remember meaning. This argues for a situated cognitive process – grounded in experience, but not always motor action. Visualisation is part of such a grounded, distributed cognition (Liu, Nersessian & Stasko, 2008), where mental imagery is used to build comprehension. Liu and Stasko (2010) detail higher-order cognitive links between external visualisation and mental models used to support understanding of visual information sources. Spatial relations are also proposed to contribute to mental models (Tversky, 1993). Indeed, there is evidence that spatial mapping is available when reading text, and aids comprehension of narrative (Haenggi, Kintsch & Gernsbacher, 1995). Zwaan and Van Oostendorp (1993) demonstrate partial spatial models in comprehension of naturalistic text narrative.

Thus, mental imagery from multiple sensory domains is used to integrate information across sentences and build semantic representations that are more easily understood and remembered. This is consistent with some interpretations of working memory, where sentences are more easily 'chunked' as one representation and thus recalled better than individual words (Baddeley, Hitch & Allen, 2009). Zwaan and Radvansky (1998) identify five sources of situational information – space, time, motivation/causation and protagonist/object. Mental maps may also require specific probes, where pairing between situation and protagonist are necessary for comprehension (Wilson, Rinck, McNamara, Bower & Morrow, 1993). Evidence from naturalistic narrative suggests multiple domains are being monitored simultaneously (Taylor & Tversky, 1997; Zwaan, Magliano & Graesser, 1995), thus any mental model used to support semantic understanding is multimodal in nature, and incorporates spatial, temporal and visual information, among others. A previously discussed, emotion is another domain accessed during text reading, however this may be dependent on literary properties and techniques of the story, as well as mental imagery (Dijkstra, Zwaan, Graesser & Magliano, 1995).

Overall, this suggests a complex, multimodal representation of semantic content derived from text, with affective and motor representations incorporated with other sources. The same can be said for physical feedback, which ranges from internal musculoskeletal and visceral to external, such as vision, motion, space and touch. Thus, not only does language evoke mental models that are situated somewhere on the continuum between pure abstraction and pure action, but that also corresponds to distinct forms of physical feedback. The interaction between semantic representation of physical information and semantic access to story-relevant conceptualisations may be confounded by these multimodal sources, only one of which is the motor representations proposed here. Text, more than sentences, may be susceptible to such interference, as narrative is built from complex space-time-character-motivation links (Zwaan et al., 1995). Balota, d'Arcais and Rayner (1990) discuss text comprehension as a process of building inferences about the narrative, including the causal function of actions and events and the intentions of characters. Meaningful links between the segments of text may be built based on various sources of information and are not limited to embodied feedback. Arguably, the longer the text, the more different sources of information are processed as part of the same narrative, introducing complexity that would not necessarily be present for individual sentences. This may explain research using narratives contradicts previous evidence from sentences.

In summary, results from Study 3 are inconsistent with previous embodied literature and with the selective effects reported by Study 1 and 2. It is debatable whether this reflects failure to find embodiment or poor control over the multiform cognitive and linguistic processes occurring in a textual format, including purely linguistic properties and competing representations from other sources of physical experience. Arguably the current methodology may have tapped into a distributed network for language processing, and not the more specific musculoskeletal, motor associations proposed to interact with positive and negative effect. This extended interpretation and implications for future research on embodiment are discussed next.

5.2.2. Extended evaluation and future suggestions

Some limitations were observed in extending the findings of Study 1 and 2 to full text. The experiment was unable to confirm the embodied effects found for valence judgments and memory of sentences. This was possibly due to methodological and statistical limitations. Specifically, accuracy on text judgments was notably more varied across items and across participants compared to previous experiments. While overall accuracy seemed high at 91%, items analysis reveals some questions had considerably lower inter-rater agreement, i.e., 60%. Some texts were potentially problematic overall. While the current materials were a good start toward developing controlled valenced stimuli, they were only piloted for reading time and responses to the memory probe, but not participant ratings of readability, nor sensibility of the narrative. Lexical factors such as word frequency, or syntactic such as garden-path sentences or complex grammatical structures, can induce ambiguity and impair comprehension (Ferreira, Henderson, Anes & McFarlane,1996; Levy et al., 2012). Centring Theory (Grosz, Weinstein & Joshi, 1995) claims that properties of text, such as appropriately placed nouns and pronouns, are particularly key for comprehension. Gaps in logical continuity may create uncertainty about events in discourse or narrative. Therefore, texts need to ensure sources of salient semantic content and logical continuity, and any unforeseen issues can affect performance. Lapata (2003) confirm that sentence structure and the functionality of verbs and nouns has important implications. The materials employed in Study 3 need to be reevaluated for grammatical complexity to ensure issues with baseline comprehension do not interference with embodiment.

In terms of valence, the sentences used in Study 1 and 2 could engage a range of distinct emotions, e.g., love, pride, joy, or fear, loss, sadness, while texts were restricted to narrow clusters in order to preserve the conceptual cohesiveness of the narrative, i.e., one text about inspiration and another about love. Not all emotions are experienced with the same strength (Fredrickson, 1998), and the physicality, i.e., embodiment, of inspiration differs from that of pleasure or love. Even assuming equal valence, words that refer to specific physical actions, such as '*embrace*', would awaken different physical representations from more abstract words such as '*imagine*' or '*hope*', thus introducing inherent differences in how the affective properties of the texts are embodied. While the current project included words of both types, the full-text materials had more substantial differences in this respect compared to the sentence items in Study 1 and 2. For example, the first positive text in Study 3 was focused on feelings of hope and inspiration, while the second was a narrative about marriage and holiday activities. Thus, this should be controlled more strictly in future experiments.

In addition, words that label emotion, e.g., ‘fear’ and ‘joy’ are processed faster and are more receptive to semantic priming than emotion-laden words such as ‘puppy’, i.e., ones that contain affective information, but do not label it (Kazanas & Altarriba, 2015). The current study aimed to avoid using words that directly label emotion categories, i.e., ‘happiness’ or ‘sadness’. This may have resulted in reduced reactivity compared to experiments that utilise labelling words. Discrete emotions, including interest and shame, are also difficult to explain only through the valence, arousal and approach/avoidance properties accounted for in the current experiment (Lench, Flores & Bench, 2011) and may be more receptive to pictorial formats, compared to texts. While the current project aimed to explore the wide range of what constitutes emotive information, and not restrict it, future research should consider the benefit of stricter definitions on which affective words are likely to carry embodied associations, or at least compare how such associations occur for concrete and high arousal versus discrete emotions.

Another limitations is lack of experimental control over strategies employed by readers during text comprehension. Anecdotal comments from participants indicated that many re-read texts, whether to improve comprehension and refresh memory prior to the recognition task, or simply for enjoyment. However, re-reading can affect performance. Amlund, Kardash and Kulhavy (1986) established that re-reading once significantly improves recall, while consequent times increase memory of details. Other perspectives suggest that re-reading improves conceptual understanding (Mayer, 1983). As the current study investigated recognition of details from text, and hypothesised this would be improved by conceptual comprehension, this introduces a potential advantage for participants employing re-reading, regardless of whether it was consciously undertaken to improve performance or not. Time of reading and time of memory probe also interact, where immediate recall is better when texts are read directly after, compared to rehearsal at a later date (Rawson & Kintsch, 2005). This suggests the experimental paradigm of Study 3 is particularly vulnerable to rehearsal advantages.

One potential benefit of this confound relates to comfort and optimal cognitive readiness. Barnett and Seefeldt (1989) report that students performed better when they were informed they could re-read texts, even if they did not eventually employ this strategy. Thus, perceived opportunity to practice is as important as actual practice, and self-paced speed is appropriate for reducing perceived task load, arguing for a mixed approach of experimental control versus comfort.

Future studies should consider other cognitive and linguistic properties. Research has shown ease of comprehension, interest and concreteness are associated with memory of sentences (Sadoski, Goetz & Fritz, 1993a). As previously established, concreteness and emotion are not equivalent and display differential patterns (Altarriba & Bauer, 2004), even if they share associations with the physical world. Proponents of the Dual-Coding theory suggest that verbal and visual representation of the same object share a 'code', which is accessed during recall (Paivio, 2014; Sadoski & Paivio, 2004; Sadoski & Paivio, 2013). Thus, verbal concepts that lend themselves to enriched visual imagery are presumably easier to comprehend and remember. Imagery is also associated with delayed recall and specific parts of the narrative, such as climactic events (Sadoski, Goetz, Olivarez, Lee & Roberts,1990). Sadoski, Goetz and Fritz (1993b) extend this to texts of different lengths. Longer narratives, 424-441 syllables compared to the current experiment's 951, also show memory advantage for concrete versus abstract concepts. Type of text matters, where literary texts are more likely to display advantages for concreteness (Sadoski, Goetz & Rodriguez, 2000). Moreover, imagery is highly correlated with emotion perceived from text, with highly consistent visualisations and elicited affect across participants (Sadoski, Goetz & Kangiser, 1988), suggesting an overlap that is not accounted for by most emotion research.

This has unavoidable implications for material development in future research and interpretation of the current findings. Texts used in Study 3 were intended as a narrative. However, they included attention to creative writing, and were anecdotally referred to by some participants as 'interesting' and 'beautiful'. The researcher developing these materials is experienced in creative writing and poetry, suggesting that artistic expression and literary techniques may have been used inadvertently. Readers' interpretation of genre can affect performance, where literary texts display slower reaction times and more memory for surface, descriptive elements and reduced memory for situational information (Zwaan, 1994). First, the texts in question may need to be redefined as literary in nature, and thus more susceptible to confounding imageability. Second, further validation is necessary to rate materials for imagery, concreteness/abstraction and other literary properties, such as metaphoricity.

Conceptual metaphor is of particular interest in this context. While the current project did not aim to study metaphoricity, the materials were also not designed to purposefully reduce or control for the presence of metaphorical language. As previously stated, the full-text materials used in Study 3 are closer to literary narratives compared to the sentences from previous experiments, and thus may include more metaphorical content. This could introduce confounds which should be explored further. Lakoff and Johnson (1980) distinguish between concrete concepts, directly physical and experiential, and metaphors, which are mapped onto existing schemata. Metaphors are discussed as the bridge between emotion and physical experience (Kövecses, 2003). In fact, they can induce stronger emotion on a neural level compared to literal language (Citron & Goldberg, 2014), and activate emotion-relevant areas such as the amygdala (Citron, Güsten, Michaelis & Goldberg, 2016). Notably, metaphoricity is important for the association between emotion and embodiment. Mapping concept to physical experience, i.e., space-time metaphors, responds to manipulation of affective properties (O'Gorman, 2017). Through the mechanism of mental simulation (Gibbs & Matlock, 2008), metaphor links to the fundamental principles of embodiment – representing ideas and physical content through a shared meaning (Gibbs Jr, Gould & Andric (2006). Thus, it is not only important to consider metaphoricity as a potential confound in linguistic research, but also as a functional part of the process through which affective language is embodied and understood.

Importantly, this project aimed to explore internal affective feedback, such as 'hunkering down' to a negative stimulus or 'opening up' to embrace positive affect, and not the space-time mappings most commonly associated with metaphoricity. However, these confounding, and possibly overlapping external representations, i.e., space and imageability, need to be taken into account when interpreting embodiment of internal feedback from muscle, movement and body posture.

Upon re-evaluation of Study 3 texts, expressions such as '*Sarah felt magical*' or '*It was a uniquely sweet moment*' carry a strong metaphorical component, while describing a garden with blossoming cherry trees and splendid colours induces imagery far beyond '*It was a busy day for Robert*' (see Appendices). First, this introduces methodological confounds, with positive and negative texts more heavy on metaphor, imagery and use of adjectives compared to neutral. Moreover, there may be unplanned differences between the metaphorical load of separate texts in the study. This can introduce unexpected variability between texts even within the emotion categories, i.e., narratives about feeling hopeful may include more metaphor than those about swimming with dolphins. As previously discussed, metaphoricity interacts with embodiment in language. Reduced accuracy on individual texts needs to be reviewed in light of this, where differences in imagery and metaphoricity could explain the wider variability in memory performance compared to Study 1 and 2. Statistically, this unexplained variance can reduce the ability to detect significant effects, thus the surprising results of Study 3 may be attributed to methodological issues.

Second, perhaps more notably, the absence of posture effects in this experiment can be interpreted as interference from competing physical representation, such as concreteness, metaphoricity and alternative sensory mappings, and not as evidence against embodiment. Until contradictory influences are better understood and resolved, Study 3 cannot be interpreted unilaterally in relation to embodiment literature.

Overall, future research should consider a baseline for concreteness and rate any imagery or metaphors used for familiarity, conceptual accessibility and space/body associations in a rigorous validation procedure. Resolving such complexities may help us understand the intricate interplay between cognitive, linguistic and embodied processes that underpin language comprehension, and in particular how they feed into each other, i.e., how imagery from the words '*blossoming tree*' is mapped onto physical experience, and how that is later mapped onto the metaphorical, yet still experiential meaning of '*blossoming youth'*. Further, we may need to separate between mappings based on visual imagery and explained by the Dual-Code theory (Paivio, 1971), extended sensory-semantic associations from space and time (O'Gorman, 2017), and motor-based mappings of action and motion discussed by embodiment models (Barsalou, 2008).

6. General discussion: implications for embodiment, emotion and language research

6.1. Summary and interpretation

The current project presents three experiments investigating the role of body feedback in comprehension and memory of affective language. Specifically, the studies explore open and slumped posture, which are expected to elicit associations with positive and negative affect, respectively. Study 1 demonstrated that posture interacts with explicit valence recognition of sentences, where reaction time on positive sentences was slower under open posture. Study 2 extended this to working memory of affective details from sentences. Contrary to the first experiment, speed of word recognition on positive items was improved by open posture compared to slumped. This indicates that emotion-congruent posture can have facilitatory or inhibitory effects dependent on the measure of performance. No posture effects were found for neutral sentences, supporting the hypotheses of the project and demonstrating that neutral language offers a suitable control condition. The third experiment explored memory of details from full text, and showed no effects of posture.

It is important to note that none of the experiments demonstrated differences in accuracy measures. This can be explained by the ceiling accuracy in Study 1 and 2, which should not cause undue concern, as the materials of the study were designed to maximise performance. Nevertheless, these results could also be indicative of sensitivity issues, as it has been noted that embodiment is reliant on sensitive measures such as reaction time (Bergen, 2007). Moreover, Study 1 observed that participants' usual posture, i.e., preferred sitting posture in daily life, also interacts with performance. The results of embodiment appear most clearly observable for participants with mixed posture. Strong preference for either slumped or open posture may affect comfort levels under experimental manipulation. While there is no strong evidence for the importance of usual posture, it could present a useful avenue for future research.

The current study observed small to medium effect sizes, demonstrating that posture affects processing of affective information in sentences. This is consistent with the fault-tolerant cognition discussed by Taylor and Zwaan (2013), where motor feedback is not strictly necessary for performance and only provides facilitation when other sources of rich semantics are not available. Further, results support Barsalou's account (2008) of cognition, as physical representations are engaged to support understanding, alongside other associations gained from experience. To clarify, the speed of comprehension and judgment can be facilitated by congruent bodily feedback, but absence of such feedback does not fully inhibit performance, as other sources of information are available. Interestingly, the present findings indicate embodied effects only on positive language, and not negative. This raises some concerns whether embodied conceptual representations are an integral part of emotion comprehension, or have a limited and not yet fully understood role.

However, a more likely explanation would be the inherent differences between positive and negative language observed in this project. Namely, negative items tend to demonstrate higher accuracy and be more easily recognised and categorised. Considering near-ceiling performance on both Study 1 and 2, the underlying valence differences could mask the effects of embodiment. This is consistent with Fredrickson (1998), who states that positive emotion is often different from negative. Fredrickson summarises that this includes less differentiation, i.e., fewer emotion sub-categories within the positive domain than the negative, less focus from research, but also poorer memory and neural representation for positive information. Conversely, neuro research has observed that positive emotion has pronounced effect on cognition, including memory, through an overlap with the neurochemistry of reward (Ashby & Isen, 1999). While these claims require further evaluation before firm conclusions can be drawn, they offer a point of caution for research, as any underlying and yet unaccounted for differences in valence may confound observations. Further, this may explain the partial evidence for emotion-body interplay observed in this project.

As noted, comprehension only partially relies of internal physical feedback (Barsalou, 1999, 2008). Language with already ceiling accuracy may reflect that accessing embodied schema is not strictly required. Since embodiment is proposed to facilitate speed of semantic processes, and its facilitation effects are claimed to stem from neural efficiency (Barsalou, 2008, Glenber, 2015), the present findings suggest that embodied feedback was not accessed for negative language, as this category was already processes sufficiently quickly based on surface characteristics without needing to recruit associated networks. Again, this confirms that bodily feedback may support conceptual understanding, but may not be strictly necessary for it when other sources of information are available. In the current study, simpler lexical and semantic processes may have been sufficient for comprehension of negative items, thus not requiring access to embodied semantic representations Conversely, other sources of rich, contextualised data beyond embodiment may have been available, for example high imageability and concreteness. This observed pattern could be interpreted in two main ways. First, it could indicate some cognitive processes remain abstract, or primarily abstract with broader representations activated only upon further necessity. Second, ceiling performance on negative items could provide evidence for widely distributed situated cognition, where perceptual, as well as internal bodily schemas are accessed for representation.

This may be more consistent with Barsalou's approach to situated cognition (2008), which emphasises the importance of perceptual symbols, with some mixed support for Glenberg's claims that embodiment underpins the interplay between thought, perception and action. Regardless, the current project demonstrates that internal bodily feedback is accessed as part of language comprehension, which supports the tenets of embodiment and contradicts earlier models of cognition that interpret environmental input and higher-order cognition as separate processes (Fodor, 1983). Perhaps most notably, the present findings support models of embodied emotion (Prinz, 2005), demonstrating that positive and negative affect can be conceptualised in terms of approach and withdrawal from the environment, and this is clearly observable in bodily behaviours, namely expansion or constriction of full body posture. A likely explanation for this dichotomy is evolution, where emotion and especially its interplay with motor feedback and bodily states is proposed as a key mechanism to survival, procreation, as well as the evolution of cognition (Glenberg, 2015).

The current results support previous observations of embodiment of emotion, such as evidence for facial feedback recruited during language comprehension. Glenberg, Havas, Becker and Rinck (2005) and Havas, Glenberg and Rinck (2007) investigate positive and negative sentences under two face manipulations – holding a pen horizontal between the teeth, which forms a 'smiling' grimace, and holding the pen between tightly squeezes lips, which elicits a frowning response. Smiling was found to improve valence recognition of positive sentences, and vice versa, demonstrating that muscle feedback from the face is accessed to provide relevant affective information. The present project aimed to explore the same mechanism, extending this to full-body muscle groups.

This is supported by research which observes self-reported activation in various parts of the body as a response to emotive language. Niedenthal, Winkielman, Mondillon, and Vermeulen (2009) report heat maps representing the location and strength of feeling experienced after reading short vignettes. Positive emotions, such as pride, love and ecstatic joy show heightened activation in the upper body – head, arms and shoulders, chest. For an emotion such as love, this would presume the sensation of warm glow. In contrast, negative emotions such as sadness, shame and guilt show very low activation, with none in the arms and shoulders, which would be consistent with closed off posture. These patterns are confirmed by motion tracking research on emotion expression. When participants are asked to play out a simple action under the influence of different affective states, negative emotions are depicted with lowered head and slumped shoulders, while positive emotion is expansive, broad and fast (Crane & Gross, 2013; Gross, Crane & Fredrickson, 2010). The present findings confirm that dichotomy in still posture and not only motion, thus providing not only support for the link between physical and mental representation of emotion, but also demonstrating that posture can be effectively induced within experimental conditions. Arguably, the current paradigm utilizes a rather simple and accessible experimental manipulation compared to studies that involve inducing motion and walking conditions (Michalak et al., 2009; Kang & Gross, 2015). This provides a relevant update to past research.

The current project raises some intriguing questions, as it demonstrates embodiment in both explicit and implicit comprehension, but with opposite effects. Study 1 shows that recognition of positive valence is impaired under the 'positive' open posture compared to slumped, while Study 2 displays that open posture improves memory of positive details. However, these different patterns of results do not necessarily contradict the tenets of embodiment. Barsalou (1999) observes the difference between conscious and unconscious processes, and suggests that conceptual access to perceptual symbols is primarily based on unconscious neural representation, and not effortful recollection. This may explain why Study 2 demonstrates facilitation based on embodiment, while Study 1 suggests that congruent posture actually inhibits performance. Specifically, Study 2 requires only implicit comprehension and re-activation of the affective feedback, where such information only supports access to memory of emotive words. Meanwhile, the explicit valence categorisation employed by Study 1 necessitates conscious access and evaluation of the affective content, thus reflecting a different conceptual mechanism.

Further research may be necessary to untangle the conscious versus implicit processes involved, and specifically whether both are subject to embodiment. The current project suggests that embodied effects occur in both circumstances, however facilitation is possible only when access to grounded feedback is automatic and unconscious. Neural activation would need to be investigated to explore whether inhibitory effects during conscious access is explained by competition for resources. Specifically, if the automatic activation of embodied emotion and its physical feedback are located in the same neural substrates engaged in conscious assessment of emotion content, this could suggest that this neural system is taxed with performing two functions simultaneously and thus resulting in competition and slower access.

While the first two experiments of this project demonstrate evidence of embodiment, the third study is more controversial, showing no observed differences based on posture. This could suggest that the interaction between posture and affective language does not extend to full text, and is only detectable in sentence and word format. This is consistent with general guidance for embodiment research (Bergen, 2007), where shorter and tightly controlled items are most sensitive to experimental manipulation, and could potentially signify that text formats are not suitable for exploring embodiment, and research should focus primarily on sentences. However, an alternative explanation is offered by the nature of the texts used within this project, as discussed in Chapter V, and whether they truly interact with internal bodily feedback and motor processes, or other forms of situated cognition. Taylor and Zwaan (2009) review literature demonstrating embodiment, and conclude that motor experience is reactivated and used to support understanding of abstract concepts. Crucially, these effects are observed for language about actions, and, from a linguistic perspective, focus on verbs only. Arguably, language that does not directly refer to actions or motor functions may not elicit the same neural overlap, and thus reflect less familiar and potentially less pronounced forms of embodiment.

Combined with the inadvertent use of imagery in the Study 3 materials (see Chapter V), this could explain why sentences, but not text, demonstrate posture effects. Barsalou (1999) states that perceptual symbols are encoded with abstract semantic representations, and that any and all available information from the environment, including vision and visual imagination, is used to support understanding (Barsalou, 2008). Imagery is known to improve memory of details from text (Eberman, & McKelvie, 2002) and facilitate comprehension for typically developing readers and those with disabilities alike (Chan, Cole & Morris, 1990). Visual imagery appears possible even for congenitally blind people (Aleman, Van Lee, Mantione, Verkoijen & de Haan, 2001) when supported by spatial relations and haptic information, i.e., touch. Thus, it is a strong source of information, and easily recruited to support comprehension even without prompts.

Text, as a longer format that involves a storyline and a detailed environment, is perhaps more susceptible to the importance of imagery than sentences. Zwaan (1999) highlights that motor experience is recruited by mental models of text and provides more enriched representation compared to imagery alone, which would be consistent with internal feedback from the body taking precedent. However, the mental models discussed by Zwaan (1999) and Glenberg

(1997) are based on narrative text that describes situational and physical details, such as riding a mountain bike. These event-and-action-based storylines require simulation of spatial and visual information, such as locations, objects and directions. Currently, little research has explored texts of a literary nature, or otherwise language that focuses on emotions or aesthetic appreciation. Thus, it is difficult to predict whether visual imagination, such as picturing a cherry blossom garden (Text 1, Study 3), spatial relations or motor information would be the most available linguistic information in ecologically valid narrative or literary texts. Unlike many items used in classic embodiment research, naturalistic text introduces unexpected confounds and a complex interplay between multimodal influences. This suggests that the current results should not be interpreted as evidence against embodiment, but rather as indication that complexity of text comprehension requires more consideration before effective experimental paradigms are possible. Text formats may also need to be interpreted in relation to the broad definition of situated cognition per Barsalou's early account (1999), which includes any information learned through the environment, and not strictly internal feedback.

Overall, despite some contradictory findings, the current project offers a meaningful contribution to how we understand embodiment in language. The present experiments extend previous research on affective embodiment to the full body. Previously, experimentally controlled manipulations of emotion have been restricted to the face (Glenberg et al., 2005; Havas et al., 2007). While these studies demonstrate that 'smiling' and 'frowning' elicit affective associations, the current project extends this to posture, which involves more comprehensive musculoskeletal feedback. Niedenthal, et al. (2009) established manipulations on the face activate the corresponding muscles. This suggests that bodily effects also recruit multiple skeletal groups. The most likely sources of direct physical feedback are the head's position, shoulders, arms, back and legs, all of which have been known to indicate emotional states (Wallbott, 1998) consistent with the 'negative' slumped and 'positive' open postures employed here.

The current project also extends the observed facilitation of valence judgments to measures of working memory (see Chapter IV, Study 2). Previous research using experimental manipulations of the face and body has explored autobiographical memory (1983). Studies have consistently demonstrated that posture (Dijkstra, Kaschak & Zwaan, 2007) and motor actions (Casasantro & Dijkstra, 2010) influence access to autobiographical information, including of positive and negative events. Few studies have explored memory of affective words that are not retrieved from autobiographical experience (Michalak, Mischnat &

Teismann, 2014; Michalak, Rohde & Troje, 2015). Thus, the current results provide much needed support for the assumptions of embodied cognition (Glenberg, 2010) and embodied emotion (Prinz, 2005), specifically that the proposed interplay between physical feedback and mental processes does not require conscious re-experience of emotion. Personal experience is used to support understanding as a whole, knowledge acquired through experience accessed to construct mental representations even for unfamiliar concepts, as demonstrated here in Study 1 and 2. Previous investigation into embodied semantic focuses primarily on the word level and not sentences or text (Vigliocco & Vinson, 2007), thus the current experiments delve deeper into the variety of naturalistic language formats.

Further, the project provides the early steps of a highly necessary process to control and validate language stimuli used in research, namely ensuring items with comparable length and thus more precise reaction time measures, building sentences with consideration of valence ratings for individual words, and not only as a whole, and controlling for arousal and dominance. Previous research has indicated that single words can be used as affective 'labels' and successfully used for valence recognition (Wu, Chuang & Lin, 2006). This suggests that considering valence on the word level is important for ensuring consistency. The association between valence and arousal is also important (Citron, Weekes, & Ferstl, 2014), where positive and negative words usually display higher arousal compared to neutral valence (Bradley & Lang, 1999; Redondo, Fraga, Padrón, & Comesaña, 2007), introducing potential confounds in previous research. The current project provides a more fine-grained investigation of valence than previous studies (Glenberg et al., 2005; Havas et al., 2007), which compare positive and negative emotion without consideration of the middle of the spectrum, i.e., neutral language. The present findings demonstrate not only that posture interacts with language comprehension, but that this is inherently based on the presence or absence of corresponding affective information. Thus, hunched shoulders affect judgments on positive sentence not only because they provide physical feedback, but because this feedback is encoded with a directly corresponding emotional state. Neutral language, while receiving the same influence from posture, does not respond to it, as the association is not present. This provides stronger evidence for embodiment.

Combined with examples from motion tracking research, the current results support the claims of embodiment theorists, specifically that the interplay between physical experience and mental processes is bidirectional (Glenberg, Witt & Metcalfe, 2013) – while mental events and experiences such as emotion influence the body, as observed in consistent physical reactions to different affective states, the opposite is also true, and the mind accepts affective information from the body and incorporates it in decision making and abstract judgment processes. Further, the current project demonstrates that this interplay is conceptual in nature, consistent with the interpretation of Barsalou (1999) and Glenberg (2010), as interaction occurred even when participants were not aware of the affective content of the language items, and were not asked to imagine, re-experience or otherwise feel the emotion described. Thus, comprehension of valence is not dependent on felt emotion, and any interaction with physical feedback occurs on the level of understanding and concept formation. Glenberg (1997) suggests that situational models formed during reading contain reference to physical states and environmental input. In the case of emotion, this would include relevant affective detail, such as how *embracing with warm affection* looks, feels and what it means. The present findings show that such models are not formed consciously as they do not require awareness of the emotive content, further supporting Zwaan's (1999) claims for automatic, involuntary access to both imagery and embodied information.

One point of caution is that the interplay between external imagery and internal body feedback is less known. While comprehension would arguably rely on both (Barsalou, 1999), experimental manipulations such as the ones used in this project only tap into one source of feedback, in this instance interoception, and may not reflect the full process, nor the full extent of situated representations. Future research should consider exploring both avenues simultaneously, or striving to distinguish between the relative importance of the visual, haptic and internal senses. In summary, the current project establishes meaningful new avenues for understanding embodiment in language, and presents the first step to exploring how full body feedback is encoded as affective information. Any further developments would benefit from critically evaluating what we know so far, and attempting to untangle some of the confounding factors that limit our insight into embodiment.

6.2. Evaluation and implications for future research

When interpreting the results of this project, it is important to consider influences beyond embodiment which may also underpin or facilitate language processing. Inherent differences between emotions have been observed. Broadly, positive affect is less distinct than negative, and separate emotions, e.g., interest and hope, are also appraised differently (Ellsworth & Smith, 1988). This is confirmed by lower inter-rater agreement (Chapter II) and lower accuracy (Chapter III) on positive sentences in this project. Smith and Ellsworth (1985) report that happiness and pride show striking similarities in cognitive appraisals, such as high pleasantness and high control, while interest and hope are perceived as less pleasant than the former, and controlled by the environment and not the self.

As previously discussed, control and agency are key for the embodiment of positive affect, where dominance corresponds to open, expansive and approach-based postures. Thus, some emotional states, regardless of valence, may be less receptive to embodiment, or display controversial physical representations, such as pleasant, but not expansive. A ‘powerful’ or ‘relaxed’ stance, with wide shoulders, lifted head and open arms may be associated with pride and joy, but not other states of equal valence, such as inspiration or aesthetic appreciation. Not only are some emotions less activated in the body, but not all distinct states within a category are equally associated with approach and withdrawal, and thus with the postures employed within this project.

To a degree, this may correspond to abstraction versus concreteness, where emotions rated as ‘concrete’ have stronger physical representation. As previously discussed, high emotion does not equal high concreteness (Altarriba & Bauer, 2004; Altarriba, Bauer & Benvenuto, 1999), and concreteness improves memory and comprehension of text (Sadoski, Goetz & Fritz, 1993b; Sadoski, Goetz & Rodriguez, 2000). Further, emotion-laden words are less susceptible to semantic priming than ‘labelling’ words such as ‘sadness’ and ‘pride’ (Kazanas & Altarriba, 2015), and the embodied facilitation proposed in this project is semantic in nature, through shared representation of meaning and physical content.

Research may also need to distinguish between embodiment of emotion, per se, versus embodiment of affective states that are embodied by nature. While ‘*beauty*’ is equally positive as ‘*hug*’, one of them may be more embodied than the other. Another way to conceptualise this is high-approach, such as desire or success, versus high valence, but low approach emotions, e.g., passive appreciation. During the pilot study of this project, sentences describing love, marriage, family, pride and success displayed higher inter-rater agreement when categorised as positive compared to ones describing amusement or artistic appreciation, even if both were above the required valence cut-off. Emotions are shown to differ in intensity based on strength of experience, influence on actions and behaviour, physiological activation, perceived body changes and passivity/activity (Sonnemans & Frijda, 1994), as well as cognitive appraisal (Sonnemans & Frijda, 1995). This suggests intensity is intrinsically related to physicality and embodied experience. Thus, affective materials used for embodiment research may need to be constrained to concrete words, and potentially even ones high in 'physicality' loading, such as '*embrace*', '*smile*', '*cry*', '*cowe*r', or '*huddle*', as they more strongly correlate with bodily experience.

This is consistent with other suggestions that embodiment research requires very specific, highly consistent items that directly tap into motor action and even the directionality of motion, i.e., forward or backward (Bergen, 2007). Considering the results of the current project, including partial effects in Study 1 and 2 and no observed effect in Study 3, an argument can be made that the embodiment of emotion, more than other areas in the field, requires experimental control over confounds before statistically significant effects can be detected.

As previously discussed, this includes the valence, arousal, dominance and item length ratings considered here, but also concreteness, imagery, metaphoricity and 'physicality'. Extensive ratings for concreteness exist (Brysbaert, Warriner & Kuperman, 2014), but rarely overlap with detailed valence ratings. Lynott and Connell (2009) additionally report loadings of perceptual strength, i.e., visual, auditory, haptic. Research suggests that perceptual strength explains lexical performance better than concreteness and imageability (Connell & Lynott, 2012). This is explained by an overlap, where imagery is high on visual loading, and concreteness recruits multiple senses. Thus, perceptual loadings may be an even more suitable, and necessary, confound to consider when developing language materials. As discussed in Chapter V, imagery (Sadoski & Paivio, 2004), spatial mappings (Casasanto, 2009; O'Gorman, 2017) and motor embodiment (Barsalou, 2008a, 2008b) are all sources of situated feedback that support language processing. There is disadvantage for processing tactile words and switching between touch and other senses (Connell & Lynott, 2010), therefore focusing on body- and touch-related language in isolation may be appropriate for experimental control over materials, as well as more consistent with the principles of embodiment. While existing databases are an invaluable resource, controlling for the range of properties discussed above would require combining data from separate sources or collecting further ratings, which was deemed beyond the scope of the current project.

Further, it is worth considering whether individual affective words, in particular verbs, are more appropriate for investigating embodied effects, before this is extended to sentences or texts. Research offers suitable paradigms such as the Semantic Similarity Judgment Test (Kemmerer & Gonzalez-Castillo, 2010), which activate motor areas of the brain (Kemmerer, Castillo, Talavage, Patterson & Wiley, 2008) and can be adapted to use affective language, rather than the traditional hand, body, auditory and abstract words. This may reduce variability and thus increase sensitivity to the efficiency-based, neural facilitations proposed by embodiment.

Lastly, participant characteristics are a potential limitation. Specifically, the current project recruited volunteers who were not native English speakers. Evidence suggests that non-native speakers show reduced physiological reactivity to emotional verbal stimuli, specifically taboo words and reprimands (Harris, Ayçíçeğí, & Gleason, 2003). Skin conductance of bilingual participants is stronger for their first language (L1) than second language (L2). This is supported by self-report measures. Multilinguals rate the perceived emotional strength of swearwords highest for their first language (Dewaele, 2004). A review of the literature suggests that processing affective information in L1 is more automatic and stronger on a physiological level (Pavlenko, 2012). Furthermore, second language users show different embodiment patterns for L1 and L2. This poses concerns for this project, as the proposed embodiment of emotion may not occur in the expected way for L2 speakers.

Nevertheless, the recruitment of non-native speakers does not necessarily put the results of the project into question. Proficient non-native speakers who acquired their L2 early and in a naturalistic setting show reactivity to emotional stimuli, rating the affective intensity of words as stronger compared to non-proficient learners (Dewaele, 2004). Ponari et al. (2015) investigated lexical decision on positive, negative and neutral words and found that native and non-native English speakers process valence similarly. The differences between reactivity to L1 and L2 words may also be restricted to specific language categories such as taboo words or swear words, and not affective language in general (Garrido & Prada, 2021). Thus, utilising non-native participant samples may be acceptable for embodiment research when L2 speakers are fully fluent and the type of stimulus is carefully controlled.

Future experiments should be informed by the limitations discussed above. This project made the first steps toward developing and validating a set of valenced stimuli for embodiment research. While extending this to full text was less successful, it does highlight the importance of stimuli that are statistically controlled, semantically sensible and sensitive to reaction time measures. Future research is necessary to further develop and validate materials, from individual words to sentences and eventually texts that address the linguistic confounds discussed above. Follow-ups from the experiment reported here should include collecting participants ratings for valence, arousal, dominance, perceptual strength and/or concreteness, as well as readability and metaphoricity, all of which may impact on the specific mechanisms through which emotion is embodied and represented in language (see Chapter V). The pilot study (Chapter II) included categorical ratings for valence, however continuous ratings may be better able to map the subtle, yet key differences between distinct emotions within a category (Ellsworth & Smith, 1988; Smith & Ellsworth, 1985). Additionally, factor loadings across these multiple domains need to considered on an item level, exploring not only the concreteness or valence of language, but also how they interact, and whether overlapping patterns can be detected. This thesis argues that such a process is necessary before further experimentation with posture manipulations, as the postulated embodied effects may not occur and may not be distinguishable from confounding influences if language items elicit more disembodied or extended physical representations than bodily ones.

Finally, the bidirectional nature of embodiment can be explored further by establishing whether language, specifically reading sentences and texts, produce the physical patterns associated with 'negative' slumped posture and 'positive' open one. Previous research has had some success observing differential posture and motion responses to producing affective language, i.e., writing down memories of emotion from personal experience (Kang & Gross, 2015; Oosterwijk, Rotteveel, Fischer & Hess, 2009). Future research should extended this to comprehension, beyond self-referent autobiographical memory. The current project demonstrates that posture can affect language beyond the self; more is necessary to confirm this pattern from the opposite perspective – language affecting the body. First, that would establish whether participants only engage embodied representations in relation to the self, as previously suggested (Markman & Brendl,2005), or across social and situational context (Barsalou, Niedenthal, Barbey & Ruppert, 2003). Second, it would demonstrate whether direct re-experience of a remembered feeling is required, or bodily information is recruited for the very process of comprehension, beyond own experience, as some models of embodiment suggest.

6.3. Conclusions

In summary, the current project provides evidence that semantic processing of emotion in language interacts with emotion associations in body posture. This interplay is observed in both explicit recognition of valence and implicit comprehension, as indicated by memory of affective details. It is important to note that explicit processes, i.e., consciously observing and judging valence, show competition for resources under a congruent posture condition, while implicit processes that are automatic and do not require effortful access are facilitated by congruence. This has important implications for understanding the proposed neural overlap between conceptual and embodied semantics. Specifically, this suggests that neural priming based on already activated physical feedback from posture is more effective in supporting automatic processes and benefits efficiency more than the strength of activation or awareness of affective content, which is consistent with previously observed patterns in embodiment research (Barsalou, 2008).

Neither facilitation, nor inhibition was observed for memory of texts, which reflects the complexity of text comprehension, where imagery and use of creative metaphor have a more pronounced cumulative role. Future research is necessary to explore the relative importance of interoceptive physical feedback, i.e., muscle activation from posture, and perceptual associations such as imagery and concreteness, which are known to aid memory (Paivio, 2014; Sadoski & Paivio, 2004), as well as identification of emotion from text (Sadoski, Goetz & Kangiser, 1988).

The present findings support embodied models of cognition, which state that processes previously thought to depend primarily on conceptual representations, for example language comprehension, also rely on environmental information (Barsalou, 2008) and physical, motor feedback in particular (Glenberg, 2010, 2015). This project also supports theoretical models of emotion embodiment, demonstrating that positive and negative affect are understood through associations with typically co-occurring physical feedback (Prinz, 2005). While previous literature has observed that for motion and action sequences (Michalak et al., 2009, 2014), the current project extends this to still posture, end continues to establish that physical manipulations can induce affective associations in language. Overall, this provides evidence for embodiment, although it is important to further investigate the underlying difference between positive and negative valence and the rather uncertain role of positive emotion (Fredrickson, 1998), and whether some valence categories are more sensitive to embodiment than others.

Beyond cognition, this project has implications for understanding and treating mood disorders. Specifically, physical interventions can guide patients to adopt a more expansive and relaxed posture or perform broad, stretching movements, thus reducing the slumped, chin-down physical positions strongly associated with depression (Michalak et al., 2009). Some studies have noted that posture interventions can improve mood and energy levels in depressed patients (Wilkes, Kydd, Sagar & Broadbent, 2017), as well as alleviate the negative memory bias, specifically memory of negative language (Michalak, Mischnat & Teismann, 2014). Thus, preventing the negative feedback loop between negative emotional experience and the corresponding slumped posture can be effective in improving symptoms of depression, much the same way as cognitive behavioural therapy aims to promote self-awareness of sad thoughts and feelings and offer alternatives.

These principles have been put into practice by mixed therapeutic approaches. Research has observed that yoga interventions reduced depressive symptoms (Shapiro et al., 2007; Woolery, Myers, Stemliebm and Zeltzer, 2004). Yoga is also found to improve neuro-cognitive performance in clinical depression, specifically executive function and working memory (Sharma, Das, Mondal, Goswami, & Gandhi, 2006). With evidence for this benefit accumulating (Cramer, Lauche, Langhorst & Dobos, 2013; Louie, 2014), it is increasingly prudent to evaluate the mechanisms behind this improvement. Bridges and Sharma (2017) observe that yoga activates most of the body's muscle groups, promotes relaxation and actively encourages exercises to improve the mind-body link and thus unite cognition with internal awareness of the body. As such, the principles of yoga may well tap into the same body-mind associations proposed by embodiment research, with positive effects on mood and memory explained by the facilitatory effects of expansive posture and motion and increased muscle activation. This perspective, in particular investigation of the neural and musculoskeletal mechanisms, offers a valuable avenue for future research with applications in the clinical and therapeutic field.

To conclude, the current project demonstrates that body posture can elicit conceptual associations with emotion, independent from felt emotion or conscious awareness of the affective content. Further, the project supports the notion that such embodied effects can be observed in language comprehension and memory. The role of the body warrants further exploration, in particular attempting to disentangle the comparative roles of interoceptive muscle feedback, broader spatial and motor awareness, imagery and more. Posture effects, which are interoceptive in nature, may be most clearly observed in comprehension of emotion words and states that involved muscle activation, such as '*embrace*' or '*cower*', while language of equal valence, but referring to aesthetics or general pleasantness, could be more susceptible to imagery. Other avenues of research include confirming the bidirectionality of posture-language associations, specifically whether reading sentences and texts such as the ones presented here also elicits the corresponding posture. With some limited support from word-generation and autobiographical affective memory tasks, this offers a suitable line of further study for the embodiment of emotion.

7. Appendices

7.1. Appendix A. Pre-registration documents for Study 1, 2 and 3, respectively. Taken from AsPredicted.org

ASPREDICTED

Wharton CREDIBILITY LAB UNIVERSITY OF PENNSYLVANIA

CONFIDENTIAL - FOR PEER-REVIEW ONLY

Embodied emotion: bodily feedback and comprehension of emotion in language (#6942)

Created: 11/25/2017 08:29 AM (PT)
Shared: 11/25/2020 01:06 PM (PT)

This pre-registration is not yet public. This anonymized copy (without author names) was created by the author(s) to use during peer-review. A non-anonymized version (containing author names) will become publicly available only if an author makes it public. Until that happens the contents of this pre-registration are confidential.

1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
Physical posture associated with either positive - open posture, or negative emotion - closed posture, will influence recognition of valence in language. It is expected that congruent emotion in posture and language will facilitate performance, while incongruence will impede it.
Thus, the first hypothesis is that recognition of positive sentences will be faster and more accurate in the open posture condition compared to the closed.
The second hypothesis is that, conversely, negative sentences will be more accurately and quickly recognised in the negative posture than the positive. The third hypothesis is that neither posture will have an effect on neutral sentences.

3) Describe the key dependent variable(s) specifying how they will be measured.
The dependent variables will be accuracy, measured in percentage, and reaction time in milliseconds on valence recognition of 90 positive, negative and neutral English sentences.

4) How many and which conditions will participants be assigned to?
The experiment will use a 2x3 repeated measures design. The main experimental conditions will involve two posture manipulations - open or closed sitting posture. Participants will take part in both conditions in counterbalanced order. However, the experiment will also involve rating three separate categories of English sentences - with positive, negative and neutral valence. Participants will again rate all categories, with sentences presented in semi-randomised order.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
A pilot experiment validating the materials showed that ratings of positive sentences is significantly more consistent than negative items. This could potentially confound the effects of posture with pre-existent differences if the sentence categories are investigated simultaneously.
Thus, three separate repeated measures Analyses of Variance will be conducted to investigate the differential effects of the posture conditions on accuracy of recognition for positive, negative and neutral sentences, respectively. These analyses will be corrected for multiplicity of testing.
The same procedure will be followed for the second dependent variable, reaction times of judgments. As accuracy and reaction time are arguably different measures of performance, and can show trade-off effects, investigating them in separate analyses will not be corrected for multiplicity.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
First, sentences will be investigated for consistency of ratings. Items that have less than 60% agreement of ratings across the sample will be excluded.
Second, mean reaction times (RTs) will be computed on within-participant and between-participant levels. For each participant, RTs on individual items that are 2.5 standard deviations (SDs) above the mean for this participant will be excluded. On the sample level, participants whose average RT is 2.5 SDs above the sample mean will be excluded.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
The experiment will employ a sample of 60 individuals. However, exclusion of outliers is possible based on the criteria identified above. Thus, in the case of exclusion, additional testing will be undertaken to result in a final sample of 60 participant observations for the analyses.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)
The study will collect additional information, such as native language, education level, comfort during both experimental conditions, everyday sitting posture and level of posture preference. Participants will also be asked whether they suspected the purpose of the experiment, as they will not be informed that posture is expected to interact with the emotion in language. Some of these variables may be considered in further, exploratory analyses. In particular, posture preference may be considered a covariate, as it can affect the success of the posture manipulation.

AsPredicted

Effects of body posture on implicit comprehension of emotion (#8954)

Created: 03/08/2018 09:01 AM (PT)
Shared: 03/13/2018 01:52 AM (PT)

1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
The study aims to explore whether open and closed (or 'slumped') posture can interact with emotional content. Specifically, the experiment will investigate whether implicit comprehension and memory for negative, neutral and positive language will be affected by posture manipulations. A previous experiment by the research team established that the three emotive categories are processed differently, with and without posture manipulation. Thus, separate hypotheses will address each type of emotive language. In addition, the prior study showed differences with a direction contradictory to expectations and background literature. This study is also the first to use this specific paradigm. Therefore, the hypotheses will not specify a direction of the effect
First, we hypothesize that: a) there will be differences in reaction time of reading positive sentences based on open versus closed posture; b) posture will also affect reaction times on negative items; c) there will be no differences in neutral items. Second, we also hypothesize that these same differences in reaction times will be present in word recognition, in addition to reading times.

3) Describe the key dependent variable(s) specifying how they will be measured.
The experiment will have two main dependent variables, both based on reaction time (RT) of responses. The first dependent variable will be RT to reading and comprehension of sentences. Participants will be asked to indicate as soon as they have read and understood each sentence trial. The second dependent variable will be response RT to a memory verification question immediately after each sentence. Participants will be asked to indicate which of two words was present in the prior sentence as soon as possible. The speed of these two responses - initial comprehension and memory verification - will form the main dependent variables for each affective category (positive, negative and neutral sentences).

4) How many and which conditions will participants be assigned to?
The study will use a 2x3 repeated measures design. Participants will take part in six conditions: two based on posture manipulation (open or 'slumped') x three based on emotion category of sentence stimuli (positive, negative or neutral). Participants will take part in all conditions. The posture manipulations will be in set, counterbalanced order, either open-slumped or slumped-open. The emotional sentences will be presented in a randomized order.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
The results will be analysed using one-way Analyses of Variance (ANOVAs). There will be two main groups of analyses based on the two dependent variables - one for reaction times on initial comprehension (reading times) of sentences, and one for RTs on the memory verification task. Withing each such cluster, individual analyses will be conducted for positive, negative and neutral sentences, in order to identify whether there are differences in scores for open versus 'slumped' posture. These three ANOVAs will be statistically corrected for multiplicity of testing. However, the results will not be corrected for the two main clusters, as each will test reaction times on different responses and functions (comprehension versus memory).

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
The study will include a series of cut-offs based on accuracy and reaction times (RT) on the trial level. First, the experimental paradigm itself will time out if responses are not given within 4000ms for each item. Such responses will be considered inaccurate, the RTs (capped at 4000ms by the program) will be deleted, and the entire trial (both initial and memory responses) will be excluded. Third, reaction times will only be included for accurate trials, and removed if inaccurate. Lastly, if responses to the memory probe are not accurate, the entire trial will be excluded, as that would suggest participants did not fully understand the sentence, even if they responded to it.

Next, outliers will be identified on the participant level. Single data points will also be removed if they are 2.5 SDs above or below each participant's means. Participants will be excluded if 80% of their data points are not still present after exclusions on the trial level.

Lastly, exclusions will also be based on the sample mean. An absolute cutoff of 90% will be used for accuracy. If the individual means are below that, the participant will be excluded. Participants will be removed if they are 2.5 SD below the overall sample mean on both accuracy and both reaction time measures. Finally, participants can also be excluded despite their overall means, if they had under 80% accuracy for each sentence type (positive, negative and neutral).

Importantly, these participant exclusion criteria will be based on the initial mean - after removal of timeout and inaccurate items, but before any

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Embodied emotion: bodily feedback and comprehension of emotion in language (#6942)

Created: 11/25/2017 08:29 AM (PT)
Shared: 11/25/2020 01:06 PM (PT)

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Thus, the first hypothesis is that recognition of positive sentences will be faster and more accurate in the open posture condition compared to the closed. The second hypothesis is that, conversely, negative sentences will be more accurately and quickly recognised in the negative posture than the positive. The third hypothesis is that neither posture will have an effect on neutral sentences.

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The study will collect additional information, such as native language, education level, comfort during both experimental conditions, everyday sitting posture and level of posture preference. Participants will also be asked whether they suspected the purpose of the experiment, as they will not be informed that posture is expected to interact with the emotion in language. Some of these variables may be considered in further, exploratory analyses. In particular, posture preference may be considered a covariate, as it can affect the success of the posture manipulation.

7.2. Appendix B. Posture instructions provided to participants

Instructions

Position B

1. Please sit on the chair provided. Make sure the height, back and seat are comfortable.
2. Please sit with your legs straight under you.
3. Tilt your shoulders slightly downward.
4. If possible, tilt your upper body forward. Keep a slightly curved position of the spine, with your upper body 'slumped' inwards.
5. Keep your elbows close to your body. Rest your arms against the desk comfortably.
6. Please keep your head slightly downward, with the chin gently tucked in.

Please maintain that 'slumped' position. The researcher will also demonstrate the position. Use the image bellow as an example of the posture.

Please make sure you are always comfortable and have easy access to the computer.

7.3. Appendix C. Sentences (Study 1) and word recognition task (Study 2)

Practice items:

Neu	He applied for a job in marketing.	**marketing**	utility
Pos	The mother gave the child a hug.	girlfriend	**mother**
Neg	He was struggling with the violent nightmare.	**violent**	lifeless
Pos	The teacher was praised for his wisdom.	**praised**	loved
Neu	We were watching the news after dinner.	**news**	debate
Neg	He was afraid of failing the exam.	**failing**	ruining
Neg	The homeless man was helpless and lost.	depressed	**homeless**
Pos	We went to hear the talented pianist.	**talented**	heavenly
Neu	There was a calendar above the table.	rooster	**calendar**
Neg	The bullying victim felt abused and worthless.	burglary	**bullying**
Neu	She was doing laundry in the morning.	upkeep	**laundry**
Pos	The comedy's jokes were amusing and original.	vacation	**comedy**

Item No	Valence	Sentences	Left	Right
14	Neg	The tsunami had caused a violent flood.	malaria	**tsunami**
40	Neu	The harbour was full of old sailors.	**sailors**	novelists
68	Pos	The audience thought the movie was fantastic.	**fantastic**	honest
2	Neg	His depression left him crushed and insecure.	asthma	**depression**
36	Neu	The bodyguard was standing at the door.	**door**	bridge
74	Pos	The kids were playing with great enthusiasm.	**enthusiasm**	safety
15	Neg	The victims of the attack were frightened.	**frightened**	agonied
6	Neg	She was afraid of the creepy stalker.	insecure	**afraid**
11	Neg	The old convict was tormented by guilt.	**guilt**	ruin
34	Neu	The article was reviewed by an editor.	sauna	**article**
67	Pos	She kissed her husband with warm affection.	**affection**	wisdom
4	Neg	His painful migraine had left him miserable.	insomnia	**migraine**
35	Neu	The assistant was speaking on the phone.	**phone**	tv
65	Pos	Our new teacher was friendly and helpful.	**helpful**	gentle
3	Neg	His misfortune ended in a crippling debt.	**debt**	harm
7	Neg	She was crying over the painful heartbreak.	**heartbreak**	injustice
44	Neu	The man got inside the waiting taxi.	**taxi**	lobby
42	Neu	The law firm had advertised a position.	applied	**advertised**
75	Pos	The lovers felt deep attraction and fondness.	**fondness**	courage
32	Neu	Our neighbours were away for a week.	witnesses	**neighbours**
41	Neu	The journalist was writing on his computer.	**writing**	jumping
39	Neu	The fisherman was sitting near his boat.	chauffeur	**fisherman**
8	Neg	The attack caused panic and dangerous chaos.	**panic**	hell

64	Pos	I enjoyed the author's new witty story.	relaxed	**witty**
37	Neu	The courier was knocking on the door.	newsman	**courier**
63	Pos	He thought his new girlfriend was attractive.	kitten	**girlfriend**
12	Neg	The sick beggar was abandoned to starve.	distraught	**abandoned**
45	Neu	The man was walking down the alley.	skating	**walking**
33	Neu	The analyst was working on the database.	minister	**analyst**
38	Neu	The detective was sitting in his office.	inkeeper	**detective**
71	Pos	The girl embraced her boyfriend with love.	**love**	laughter
31	Neu	He was there to supervise the meeting.	**meeting**	campaign
5	Neg	She let out pained and strangled sobs.	**sobs**	threats
66	Pos	She felt carefree and excited when dancing.	reliable	**carefree**
72	Pos	The girl snuggled in her soft pillow.	grinned	**snuggled**
9	Neg	The cruel abuse caused trauma and fear.	murder	**abuse**
13	Neg	The terrible accident had left him paralysed.	**accident**	torment
73	Pos	The girls greeted us with cheerful smiles.	faitful	**cheerful**
62	Pos	He was glad to inherit a fortune.	**fortune**	beach
70	Pos	The family shared a lovely white Christmas.	exotic	**lovely**
61	Pos	He found harmony and peace in life.	warmth	**harmony**
10	Neg	The old addict was defeated and hopeless.	bankrupt	**hopeless**
69	Pos	The child received a fancy birthday gift.	**gift**	honey
1	Neg	He was slowly dying from incurable cancer.	**cancer**	illness
43	Neu	The lecture room was full of academics.	**academics**	geologists

ItemNo	Valence	Sentences	Left	Right
27	Neg	We were assaulted by an angry mob.	robbed	**assaulted**
59	Neu	We saw the weather forecast on tv.	aerial	**weather**
78	Pos	The new graduates were full of optimism.	**optimism**	dignity
28	Neg	We were frustrated by the unfair punishment.	**unfair**	gloomy
87	Pos	This month she earned a generous reward.	accurate	**generous**
57	Neu	They were sitting at the kitchen table.	orchard	**kitchen**
79	Pos	The painter was admired for creative ideas.	secure	**creative**
86	Pos	They went on a luxury honeymoon trip.	comfy	**luxury**
23	Neg	They were chased by the vicious killer.	sinister	**vicious**
76	Pos	The music festival was lively and fun.	free	**fun**
53	Neu	They had a meeting with the accountant.	**accountant**	newsletter
58	Neu	They were speaking to the bus driver.	**driver**	aviator
19	Neg	The widow was haunted by terrible grief.	convict	**widow**
46	Neu	The passengers were waiting for the plane.	**plane**	inn
47	Neu	The ships were waiting at the docks.	limos	**ships**
82	Pos	They had a fun and romantic date.	amusing	**romantic**
89	Pos	We thought the painter's art was amazing.	**amazing**	liberating
56	Neu	They went to the nearest grocery shop.	meat	**grocery**
16	Neg	The violent war caused poverty and illness.	arson	**war**
49	Neu	The team had gathered around the table.	**table**	stairs
83	Pos	They had a happy and devoted marriage.	**marriage**	harmony
18	Neg	The war ended in loss and tragedy.	**tragedy**	frostbite
20	Neg	The widow was mourning his tragic death.	**death**	jail

54	Neu	They took part in a scientific experiment.	notable	**scientific**
48	Neu	The store was on the street corner.	hangar	**street**
50	Neu	There was a lantern on the terrace.	**terrace**	ladder
24	Neg	They were frightened by an awful scream.	**scream**	struggle
90	Pos	We visited a gallery with beautiful art.	luxurious	**beautiful**
60	Neu	We went shopping in the town market.	**town**	road
25	Neg	They were tortured by the cruel dictator.	murdered	**tortured**
29	Neg	We were hurt by their rude insults.	**rude**	fatal
55	Neu	They watched the street from the window.	**window**	sunroof
88	Pos	We laughed at the play's witty humour.	**humour**	peace
17	Neg	The virus was causing fever and nausea.	**nausea**	starvation
30	Neg	We were plagued by loss and failure.	**failure**	poison
84	Pos	They thought the comedian was very funny.	**funny**	cute
21	Neg	Their arrogant boss was hostile and grumpy.	creepy	**arrogant**
52	Neu	There was a train passing through town.	boat	**train**
26	Neg	They were upset by the bitter argument.	**argument**	insult
51	Neu	There was a photograph on the wall.	**wall**	post
81	Pos	The young lovers shared a sensual kiss.	**kiss**	sweet
22	Neg	They suffered an angry and bitter divorce.	**divorce**	hangover
77	Pos	The new comedy made the audience laugh.	**laugh**	feast
85	Pos	They welcomed us with a genuine smile.	joke	**smile**
80	Pos	The writer's new book won an award.	**award**	payday

7.4. Appendix D. Texts and corresponding questions, Study 3

Study 3. Affective texts.

Positive 1.

One lovely morning Sarah decided to go on an adventure. She visited the garden near her home. It was pleasant and warm and the sun was shining brightly. It was a beautiful spring with radiant sunny days and peaceful evenings. That was why Sarah wanted to spend as much of it as possible outdoors, exploring the city's wonderful sights. She loved nature and she was happy to live in the perfect place. There were many charming attractions around, but her favourite was the garden. It was an oasis where she felt safe and at peace.

Today Sarah was excited, because the cherry blossoms were blooming. She was in awe of how gentle and gorgeous they were in the springtime. They inspired her to dream and imagine a happy world where everything is possible. She believed that this optimism made her more hopeful and confident, capable of wonders. That was the magic of her beloved garden and its treasures.

That was why Sarah was so cheerful today. She was smiling before reaching the garden, walking with excitement in her step. Laughing and singing voices welcomed her at the entrance. Happy couples were embracing, mothers were hugging children with affection. Sarah enjoyed the laughter and cheer for a moment, then continued walking until she reached the blooming cherries. They were splendid. Their colours were incredible, delicate and gentle, and transformed the garden into a fantasy dreamland. Sarah giggled with amazement and danced out under a fragrant rain of falling blossoms. They were like a waterfall of brightly coloured snowflakes. Sarah loved the pleasure of feeling their soft, silky petals. It was a uniquely sweet and euphoric moment. In the serenity of the garden, Sarah felt magical and blessed.

Questions (correct answer **highlighted**):

Pos1	1. What time of year was the story set in?	**spring**	autumn
Pos2	2. What was the weather outside?	moonlit	**sunny**
Pos3	3. Where did Sarah go that day?	fair	**garden**
Pos4	4. What did Sarah love to explore?	**nature**	museums
Pos5	5.The garden made Sarah feel...	**hopeful**	respectful
Pos6	6. In the garden, Sarah wanted to visit the...	pets	**cherries**
Pos7	7. Sarah danced under the falling...	**petals**	rain
Pos8	8. How did Sarah feel in the garden?	honest	**magical**

Neutral 1.

It was a busy day for Robert. He had to do chores and go to work in the office. He brushed his teeth, made toast and sat down to read the news. It was his morning ritual an an important part of his daily routine. Robert carefully planned his time. He was busy on workdays, but when he was not at work he could spend time alone and unwind.

This morning Robert's planned activities would take him to a shop that was close to his office building. He would get there by bus or he could walk. He usually avoided taking the subway as he wanted to look out and observe the city. It was a nice day, so it seemed that a walk would be suitable. Having decided, Robert took his raincoat off the rack in case it rained. He put his old, worn leather shoes on, grabbed his bag and left. He was on the staircase when a neighbour called out his name. When they passed each other on the stairs she greeted him. Robert returned her casual wave and stopped for a brief chat. He could only stay a minute before moving on and walking out of his apartment building.

Robert found himself on the dusty city sidewalk. The weather was cool and overcast, with a slight wind and the scent of rain left from the night before. The wind was carrying fallen leaves, which were gathering in ditches and in the alley corners. The air was crisp and cold. Robert gulped it in and felt the smell of smoke and wet asphalt. With a sigh, Robert started down the street. His route took him down less traversed paths, avoiding the commotion of the major roads. He passed by small stores selling clothes, trinkets or furniture. Robert reached the store he was looking for. He had to pick documents and supplies before going to the office. Then, he walked out and continued down the street more slowly. He got to his workplace with time to spare and his usual day could start.

Questions:

1Neu1	Robert's day was going to be....	private	**busy**
1Neu2	What did he have to do today?	**chores**	lectures
1Neu3	Where did Robert work?	brigade	**office**
1Neu4	What did Robert have for breakfast?	waffle	**toast**
1Neu5	Who stopped him on the staircase?	**neighbour**	technician
1Neu6	What did Robert decide to do?	**walk**	drive
1Neu7	What did he encounter along the way?	bistros	**shops**
1Neu8	What did Robert pick from the store?	**supplies**	toner

Negative 1.

It was a dismal and gloomy morning. The graveyard was abandoned and lonely, with broken headstones scattered around the ruins of and old crypt. In the darkened gloom, a widow limped toward a lonesome grave. The widow slumped over the cracked tombstone, tears falling. She was trembling, ovewhelmed by suppressed sobs. Her grief was as miserable and desolate as the graveyard itself. Since the untimely death, she was struggling not to surrender to the flood of depression that was threatening to smother her. The trauma from her loss was still raw and painful. After the misfortune that had widowed her, she was lost and helpless against the agony of mourning alone.

The funeral had been agonising. Mourners stood grim and sad around the widow as the coffin was buried. The casket descended into the grave, stealing away the man she was grieving for. He was killed by cruel accident and deadly illness. On his deathbead, she had been tortured by his pain and the threat of loneliness. She was powerless against death and had to suffer its awful burden.

The widow was even more lonely and broken after the funeral. Terrible nightmares plagued her. They tormented her with images of death and decay, of a lifeless corpse falling into the coffin and rotting away. She would weep and choke on suffocated screams of anguish. Yet, her tears were unanswered and a soulless dread paralysed her. Hopelessness and melancholy drowned her. Once stricken by grief,the widow lost the struggle to exhaustion and apathy. She was ashamed of her weakness and this wretched guilt destroyed her. He would not be afraid to die to end this misery. Still, the mourning widow wept her heartbreak and came to the lonely grave amidst the ruins.

Questions:

1Neg1	Where did the story take place?	junkyard	**graveyard**
1Neg2	This morning the graveyard was...	overrun	**abandoned**
1Neg3	Who started walking through the ruins?	**widow**	vagrant
1Neg4	The widow was trembling with suppressed...	fear	**sobs**
1Neg5	What was she helpless against?	**mourning**	starvation
1Neg6	What was the widow plagued by?	disaster	**nightmares**
1Neg7	What did she see in her dreams?	**corpse**	cripple
1Neg8	The widow was drowned by	**hopelessness**	betrayal

Negative 2:

It was a desolate and depressing shift at the hospital. A lifeless lull was stealing even the suppressed curses and whimpers. In the gloom outside a boy limped toward the hospital. He was reluctant and lost, creeping inside like
an unwanted thief. The stench of antiseptic and decay assaulted him. A violent cough choked him. The nurse glared over and he trembled with worry. He was afraid to confess his pain, because it was not an emergency. Still, she was
scary and stern and he told her.

Later he was on the ward with other sufferers. There were victims of accidents,trauma, dangerous burns. There were diseases like the flu, nausea, migraine and diabetes. There were other illnesses like the pox, pneumonia, ulcers. There were even broken or amputated limbs. But Charlie was there because he was being abused.

Charlie had an evil stepmother. She hated him and hurt him with cruel insults and violence. When she was angry she screamed at him that he was awful, horrible and useless. She belittled him and claimed he was a motherless orphan, unworthy and abandoned. The hateful abuse got more vicious and aggressive. The stepmother would lock him, starve him and hurt him if he complained. The injustive and loneliness were as damaging as the wounds and pain. Oppressed by the burden of blame, fear and shame, Charlie was helpless. At school he was an outcast, falling victim to bullies. Because of the neglect, he was insecure and fearful. His crippling terror was that he was worthless and shameful. Still, even crushed, Charlie struggled to flee and end his suffering.

Questions:

2Neg1	How was the hospital?	**depressed**	overrun	z
2Neg2	What were the sounds of the hospital?	quarrels	**curses**	m
2Neg3	How did the boy seem approaching the hospital?	**lost**	mad	z
2Neg4	What was the smell that assaulted him?	sewage	**decay**	m
2Neg5	How did the nurse seem to him?	lazy	**scary**	m
2Neg6	What was Charlie suffering from?	**abuse**	virus	z
2Neg7	Who was hurting Charlie?	stepfather	**stepmother**	m
2Neg8	How did the abuse made him feel?	**worthless**	overworked	z

Neutral 2:

Today the train was passing through town and heading in a different direction. A novel route had been included in its usual stops. The morning train used to make a direct line through the mountains. Now, it moved through the outskirts and followed the mountain range for a while before crossing. The afternoon service had the old routine, but it was slower. Today the choice of train mattered.

Martha knew that she needed to catch the morning one. She need to visit a town just before the final stop. There, she would visit the council meeting and talk to the mayor. It was a small task but she had to finish it before the afternoon. She decided to see the scenic route. When Martha boarded the train, nothing seemed unusual. She got peanuts and a drink and settled in to read the news. They started moving and the city was left behind. The open road was visible through the window and Martha could observe the cars. She remembered passing the length of this road by bus years ago. The difference was small, but the train was the usual for her.

By midday they had reached the tall, hulking mountain range. The shape of the train was weaving through the green outskirts. The metallic ribbon would wrap around the hillside and climb between the peaks. Martha looked up with interest. She started taking notice of the passing cars. Then, she saw the change in scenery when the train was crossing the mountain. The landscape was becoming bigger and more divided. On one side there was a wide pine forest. On the other there were towns showing industrial buildings, concrete and metal. She knew the place and that soon she would be at her stop. The morning train had a different route, but also similar.

2Neu1	Which train was being changed?	afternoon	**morning**	m
2Neu2	What was being changed?	**route**	time	z
2Neu3	Where did the change take place?	**mountains**	towns	z
2Neu4	Who did Martha need to talk to?	doctor	**mayor**	m
2Neu5	What route did Martha decide on?	cultural	**scenic**	m
2Neu6	Martha remembered taking the same route by...	**bus**	plane	z
2Neu7	What kind of forest did they pass?	maple	**pine**	m
2Neu8	What kind of buildings did they pass?	**industrial**	courthouse	z

Positive 2:

This summer John and Mary went on a special holiday. They were a young couple on their first adventure. They had just gotten married and they were excited and optimistic. This was their honeymoon and they wanted it to be perfect. They had been lucky, blessed with good fortune and the support of many lovely friends. They had loving parents who approved of their marriage and wished them all the happiness in the world. The wedding had been a beautiful and splendid occasion with cheer, joy and laughter. The couple celebrated their love and devotion among family and friends.

Now they were starting their new future. John and Mary were going to fulfil their dream of exploring their favourite sights. On their honeymoon weekend they went on a luxury trip to an exotic resort. Their pleasures included hiking in the rainforest and swimming with dolphins. They discovered treasures like a gorgeous waterfall and a village with festive, vibrant charm. John explored the seaside while Mary was relaxing in the sunny tropical warmth.

The couple enjoyed the peaceful evenings. They would build a campfire on the beach, cuddling under the blooming sunset. The colours were incredible and brilliant. Golden sunlight made the ocean sparkle. They snuggled and talked sweetly, fireflies dancing around them. Later the night welcomed the stars. John kissed his beloved wife in the moonlight, before going to the safety of their bedroom and her warm embrace. The lovers shared intimacy and affection during both adventure and peace. Every day was heaven, full of love, passion and joy. Their dream vacation was magical and as perfect as they had hoped.

Questions:

2Pos1	John and Mary had just celebrated their...	success	**marriage**	m
2Pos2	The couple's family and friends were...	**loving**	honest	z
2Pos3	How was John and Mary's wedding?	**splendid**	amusing	z
2Pos4	They were going to fulfil their...	**dream**	ambition	z
2Pos5	The location of their honeymoon was...	romantic	**exotic**	m
2Pos6	John and Mary went...	dancing	**swimming**	m
2Pos7	The couple would cuddle to watch the...	**sunset**	sunrise	z
2Pos8	What did the couple share?	prosperity	**intimacy**	m

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