Bachelor Degree Project

UNIVERSITY OF SKÖVDE

CHALLENGING THE DUAL CODING THEORY:

Does Affective Information Play a Greater Role in Abstract Compared to Concrete Word Processing?

Bachelor Degree Project in Cognitive Neuroscience
Basic level 22.5 ECTS
Spring term 2018

Ingrid Almgren

Supervisor: Judith Annett
Examiner: Sakari Kallio

Abstract

It has long been held that concrete material has a processing advantage over abstract material, as predicted by Dual Coding Theory (Paivio,1991), although this has been challenged. For example, based on evidence for behavioural and neuroscientific studies, Kousta,, Vigliocco, Vinson, & Del Campo, (2011) proposed that emotional valance had a greater influence in the processing of abstract words, and that under some circumstances there may be no concreteness effect and might even be an abstractness effect. This would not be predicted by DCT. In addition, Isen and Daubman (1984) have claimed that emotional valence, and particularly positive emotion can influence cognitive processing. Specifically, they demonstrated that positive emotion was associated with more inclusive categorization of ambiguous category members. This current study was a 2 x 2 between group design to investigate the effect of positive and negative valence on recognition memory for concrete and abstract words and on categorization. Contrary to what was predicted by Dual Coding Theory, abstract words were generally better recognized than concrete, with there being an additional interaction with valence. A significant interaction between word type and valence on categorization was also found. Results partially support Kousta et al. (2011).

Keywords: abstract word-processing, DCT, ERP, semantic representation, concreteness effect, imageability, recognition task, categorization, emotional valence

CONTENTS

1 Introduction

Much research has been carried out over a long period of time investigating how information is encoded, stored and remembered and whether or not different kinds of information are more easily remembered than others. This issue of mental representation of information has been approached from a number of different theoretical viewpoints. These fall into two basic approaches to the problem. On the one hand there are those such as Anderson and Bower (1974) and Pylyshyn (1973; 1984) who propose that mental representation is unimodal and abstract, utilizing amodal, propositional representation related to meaning. On the other hand, there are those who suggest that mental representation should be considered as being modality specific or multimodal, retaining in an analogue fashion some of the characteristics of the initial sensory input. A critical difference between the amodal and multimodal approaches lies in the role given to mental imagery (see e.g Kosslyn, 1980; 1981). Extensive review of the literature pertaining to mental imagery per se is outside the scope of this report. However, it is important to mention some key aspects. Alternative definitions of mental imagery exist, but one useful generic definition is that provided by Thomas (1999). Here, mental imagery is defined as quasi-perceptual experience: in other words, experience in any sensory modality that closely resembles actual perception but experienced without any appropriate external stimulus being present.

For decades, during the behaviourist era of psychology, mental imagery was regarded as epiphenomenal, and without any significance in relation to psychological functioning e.g. in cognition. Interest in imagery and its potential function in cognition increased again from the 1950's onwards. A key player in this renewed interest in imagery was Allan Paivio (see e.g. Paivio, 1971). He is credited with showing that mental imagery could be studied successfully experimentally and that it could play a significant role in e.g. learning. Theoretically, his major contribution was Dual Coding Theory (DCT).

The major focus of this report will be Dual Coding Theory and its implications together with consideration of alternative points of view. What follows is a selective overview of the literature relating to Dual Coding Theory and its theoretical implications, followed by presentation of some of the relevant objections to Paivio's ideas, such as the Context Availability Theory. This will lead to a brief presentation of the role of emotion in cognitive processing and mental representation, with a focus on broadening of cognitive scope and performance on tasks of categorization. Finally, the results of an empirical investigation relating to these theoretical issues will be reported. Relevant neuroscientific discussion will be included where appropriate.

Dual Coding Theory

Dual coding theory (DCT), as a conceptualization of cognition and memory (cognitive representations), has as its focus the distinction between verbal information and all other non-verbal information. This is in contrast to other general theories that assume that the language of thought is unimodal and abstract leading to so-called amodal propositional structures of mental representation. A fundamental aspect of DCT is the role of imagery. In its time this was a relatively new way of thinking about memory and cognition that had traditionally been focused on verbal/linguistic processes with little interest in other variables that might be important. (Paivio, 1991). Note that in what follows below, discussion is about mental representational systems – symbolic representation, not little 'Lego-like' bricks in the brain labeled 'verbal' or 'non-verbal'. Also, originally Paivio focused mainly on verbal representation and visual imagery, but more recently the additional role of other forms of information input - olfactory, gustatory, tactile and so on has been acknowledged (See Annett & Leslie, 1996 for a discussion).

A basic premise of the dual coding approach is that encoding processes are a major determinant of how well new information is learned and remembered, and that mental representations are modality specific, with the main distinction being between verbal and non-verbal events (Paivio, 1986)**.** The central theoretical claim is that structurally and functionally distinct, but interconnected subsystems handle two classes of cognitive phenomena. Any item can be encoded in a verbal-linguistic symbolic system, in a non-verbal symbolic system or in both. Each system has basic representational units. Verbal representations or ‘logogens’ are as described by Morton (1969, 1979), while imaginal representations or ‘imagens’ encode modality specific information about non-verbal experiences (Clark & Paivio, 1987**).** Paivio **(**1986) assumed the two systems to be functionally equivalent with better memory for an item being the result if both systems have been activated (‘dual trace’), rather than one (‘single trace’). Hierarchical stages of processing include direct activation of representational units (representational processing), referential (between-system) and associative (within-system) processing. This postulation of discrete verbal and non-verbal representational units makes dual coding differ axiomatically from those other cognitive accounts of mental representation noted earlier which assume a single amodal mode of representation (Pylyshyn, 1973, 1984**)** but compatible with the modality based imaginal representation concept defended by others, such as Kosslyn **(**1980; 1981**).** Furthermore, Paivio has himself claimed that the working memory system as proposed by Baddeley & Hitch (for example, Baddeley, 1986; Baddeley & Hitch, 1974; Baddeley & Hitch, 1994**)** could be somewhat analogous to representational processing. In the working memory formulation, a limited capacity central executive is said to utilize several optional ‘slave’ systems, with visual or spatial processes being dealt with by the visuospatial sketch pad and verbal processes by the auditory subsystem comprising the articulatory loop and phonological store.

The probability of activation of the various connections and associations between and within the two representational systems at the time of retrieval (i.e. remembering) is determined, according to Paivio, by the strength of the representations and their connections which, in turn, are based on individual experience, properties of the to-be-remembered items as well as other influences such as context, instructions to use visual imagery and so on (see Clark & Paivio, 1991).

The verbal and non-verbal systems are also suggested to differ in relation to meaning. Logogens are suggested to not possess intrinsic semantic meaning over and above the fact that they can be recognized and are familiar. On the other hand, imagens are suggested to have intrinsic meaning by virtue of the fact that they resemble in some way the entity to which they refer (Sadoski & Paivio, 1991). Furthermore, the verbal and nonverbal representational systems are said to be constrained both in relation to organizational and transformational processes. The nonverbal system is organized in a synchronous, parallel fashion allowing for more holistic manipulation while the verbal system is constrained by being sequentially organized. (Clark & Paivio, 1991). In other words, the verbal codes can be viewed as remaining as separate entities even when organized into e.g. sentences. Nonverbal representations that may include sensorimotor imagens from different modalities may potentially be combined and 'viewed' synchronously even if acquired sequentially.

Evidence to support DCT has been derived initially from behavioural studies and more recently supported by neuropsychologial evidence. This evidence will be reviewed presently, but first it is necessary to consider briefly some salient points in relation to the characteristics of language etc. particularly mental imagery, concreteness and emotional valence.

Semantic Characteristics of Language

The basis from which DCT was developed was the conceptual-peg hypothesis of word imagery effects on recall. Since ancient times people have used this ‘one-bun’, two-shoe’ (or other language equivalent) rhyming technique to aid memory. Paivio (1991) notes that a fundamental property of this technique is that it requires a dual coding interpretation: words generate non-verbal images during encoding. The ‘peg’ words are typically words that have a high likelihood of giving rise to imagery, and when combined with the to-be-remembered item provide a compound image from which the target item can be later retrieved. For example, if house is the word to be remembered, it could be visualized as a house inside a hamburger bun, so that at recall ‘one-bun’ would lead to retrieval of the image and hence the word house. According to Paivio (1991), this technique involves the three processes of DCT: specifically, representational encoding, between system referential encoding and within system associative encoding.

The salient point of this is that the memory peg words are all words that easily elicit strong images and are usually nouns that are generally assumed to be more ‘concrete’ than adjectives, for example, which are thought of as being more ‘abstract’. This reflects an important aspect of so called semantic representation and subsequent memory for information. It is possible to identify a number of different attributes of words, of which concreteness and the closely correlated imageability are but two. For example, Tryon and Bailey (1970) conducted a semantic dimension cluster analysis of several thousand words and identified several semantic representation components. These different attributes of language have important implications for memory for e.g. words, and for the predictions that might be generated on the basis of DCT. The attributes identified by Tryon and Bailey have been utilized, implicitly and explicitly, across a wide range research so it is useful to look at these before proceeding to examine how these relate to the predictions of DCT and the various types of evidence arising from DCT.

The attributes described by Tryon and Bailey have been further discussed and summarized in a handbook of semantic word norms (Toglia & Battig, 1978) as follows. *Concreteness* they stated to be the extent to which a word relates to something which is likely to be perceived in real life through the sensory- and somatosensory systems; e.g. a dog can be experienced by sight, smell, hearing (the bark) and by touch. Conversely *abstractness* reflects a lack of concreteness. Both concreteness and abstractness are related to *Imageability,* the extent to which a word evokes some form of mental image, particularly visual imagery of the referent. It is suggested that it is easier to produce a mental image of concrete compared to abstract words, i.e. abstract words are words relating to things not readily perceptible through the senses. For example, compare the word “dog” and the word “comprehension” to understand the difference in imageability for concrete and abstract words. *Meaningfulness* is an attribute referring to how difficult or easy it is to associate to other words; compare the word “hospital” to the words “valence electron”, and, if not a physicist, or especially interested in chemistry or physics it probably is easier to come up with associative words for “hospital” than for “valence electron”. *Categorizability* is about making order or sorting information; a dog, cat, budgerigar, guinea pig could all be categorized into a large category called “pets”, and many pets can then be categorized in superordinate classes as mammals and so on. This is the extent to which something can be included in a larger group sharing similar features such as dog and cat being members of the group or category ‘pets’. *Familiarity* simply is a component telling how often or seldom a word occurs in daily language and in experimental studies the term “frequency” is often used and defined when describing if a word is commonly or not so commonly used. *Number of Attributes or Features* is a component describing how many attributes are possible to connect to a word; compare e.g. “car” to “triangle”. It is plausible that this relates to associations perhaps both within and between system processing in DCT. Finally, Tryon and Bailey (1970) mention Pleasantness. Words differ in their capacity to elicit a feeling of pleasantness and some words evoke an unpleasant feeling - compare “serial killer” to “kitten”. This attribute pleasantness is often denoted in terms of positive and negative valence (Isen & Daubman, 1984).

While all of these attributes have some bearing on the rest of this report, concreteness and the related abstractness, imageability and pleasantness (valence) will receive most attention. Concreteness/abstractnesss and the related imageabilty and pleasantness/valence are of most interest in relation to DCT and will be discussed in more detail below. In the early formulation of DCT the focus was on concreteness/abstractness and imageability and then later the issue of pleasantness/valance was introduced into the discussion by critics of DCT. The other attributes are also of importance and will be introduced at a later stage. The following sections will deal with these issues in the above order.

The Concreteness Effect

As can be seen from the earlier discussion, DCT, implies that there is an orthogonal relationship between the 5 sensorimotor systems and the proposed symbolic systems - verbal and non-verbal. Much of the supporting evidence for DCT and its main predictions (e.g independence and additivity of the verbal and non-verbal systems) and both from behavioural studies and from neuropsychological studies has related to two phenomena, and both behavioural and neuroscientific evidence will be summarized below. These are *the concreteness effect* and the *picture superiority effect,* both of which in turn relate to the role of mental imagery. Furthermore, most of the literature on DCT has focused on representation and processing of linguistic stimuli or pictorial stimuli. The concreteness effect is commonly defined as the cognitive advantage of concrete information (words, concepts etc.) over more abstract information. This advantage has been demonstrated using a wide variety of methodologies. At a general level, this cognitive advantage includes both better encoding and retrieval of concrete items over abstract.

Examples of evidence from early behavioural studies includes those which show a processing advantage for concrete words in relation to speed of identification as words (see, for example James, 1975; Whaley, 1978; Rubn, 1980 cited in Kousta, Vigliocco, Vinson, & Del Campo, 2011). More recent studies of this lexical decision task confirmed the original findings (see e.g. Binder, Westbury, McKiernan, Possing, & Medler., 2005; Bleasdale, 1987; de Groot, 1989; Howell & Bryden, 1987; Kroll & Merves, 1986; Palmer, MacGregor & Havelka, 2013) although, as will be discussed below, interpretation of the findings has varied (see Schwanenflugel, & Noyes, 1996; Schwanenflugel & Stowe, 1989;).

This concreteness effect is also evident in studies relating to both speed and accuracy of memory with concrete or highly imageable items being better remembered (see e.g. Hiroshi, Suehiro, & Hori, 2002; Fliessbach, Weis, Klaver, Elger, & Weber., 2006). Other studies have examined the ease with which both adults and children learn new (novel) concrete and abstract words. Typically, adults find new concrete words easier to learn than new abstract words, both in terms of speed and accuracy (see e.g; De Groot & Keizer, 2000; Mestres-Missé, Münte, & Rodriguez-Fornells., 2009: van Hell & Candia-Mahn, 1997) even when presented in contextually constrained sentences (Mestres-Misse et al., 2009). Relatedly, studies of language acquisition in children indicate that there is a negative correlation between age of acquisition and imageabilty of the stimuli and this applies to both nouns and verbs (Ma et al., 2009). As nouns are generally higher imageabilty/concreteness than verbs, this may partially explain why the early vocabulary of children contains more nouns then verbs, at least for English speaking children. Interestingly, in the Chinese language, imageability rating of nouns and verbs do not differ as much as in English, and children learning Chinese as a first language learn more verbs than English learning children, at least in the early years. (Ma, Golinkoff, Hirsh-Pasek, McDonough, Tardif, 2009).

As noted earlier, it is generally accepted (see e.g. Paivio, 1991) that the concreteness/abstractness attribute of to-be-remembered items is very closely aligned with the ease with which a mental image can be formed (although concreteness is not just related to visual imagery, but is related to other senses as well such as tactile). At the concrete end of the spectrum lie pictures. Paivio suggests that pictures do not require 'creation' of an image per se, as the picture can be remembered as a visual image. Pictures very often produce better memory that either concrete or abstract words. This cognitive advantage of pictures over words is referred to as the *picture superiority effect.* Thus, being presented with a picture of a dog, or actually seeing a dog would, on average, produce better memory for 'dog' than seeing the written word dog or hearing the spoken word dog which in turn would produce better memory than if asked to remember the word 'truth'.

Evidence for DCT

Paivio (e.g Paivio, 1991) has claimed that there is substantial evidence to support his formulation of DCT. This early evidence, both behavioural and neuroscientific, has been summarized by Paivio (1991). For example, as reviewed by Paivio, several behavioral studies in the literature support DCT. Some of them have focused on the additivity hypothesis by comparing results from recall and recognition tasks in both synchronous and sequential processes. Madigan (1983) suggested that the code-additivity hypotheses maybe did support only recall tasks and not recognition tasks. Paivio and Csapo (1973) showed that imaging to words greatly improved the ability of participants to recall those words compared with experimental conditions where words were only spoken aloud. Further evidence came from e.g. Paivio and Lambert (1981) who showed that when bilingual participants were presented with lists of words in English with three different types of coding cues viz. copied, translated and imaged word conditions, participants in the translated condition performed twice as well as those in the copied condition and participants in the imaged condition performed four times as well as those in the copied condition. This was interpreted as support for the picture superiority effect in free recall, which is consistent with a DCT interpretation.

As noted earlier, Paivio (1991) also reviewed some of the relevant neuropsychological data available at that time. He refers to early research where, for example, pupillary reactions and other psychophysiological measures were suggested as correlates of imagery and verbal processes. He gives examples of three different types of study that he claims support DCT. These are studies about dysfunctions resulting from localized brain lesions, split brain studies and studies of functional asymmetries revealed by lateralized presentation of visual and verbal stimuli. Paivio claimed that these early studies all pointed towards support for the DCT notion of separate verbal and non-verbal representational systems and related forms of processing. More recently, a meta- analysis of neuroimaging studies was performed by Wang, Conder,,Blitzer and Shinkareva, (2010). Specifically, this meta-analysis addressed the issue of the concreteness effect and whether or not the observed effect can actually be attributed solely to the differences in imageability between concrete and abstract stimuli. The null hypothesis of the meta-analysis was that the peak coordinates of activated regions would be randomly distributed. In fact, they found different neural representation patterns for abstract and concrete concepts. Specifically, this meta-analysis of 19 studies suggested that there was evidence for stronger activiation for concrete material in the left precuneus, para hippocampal gyrus, posterior cingulate and fusiform gyrus. Abstract material was associated with stronger activation in the inferior frontal gyrus and middle temporal gyrus in the left hemishphere. This was interpreted by Wang et al. (2010) as evidence for the existence of different processing systems involving different brain structures, depending on whether or not concrete or abstract material was being processed.

However, not all more recent studies give unequivocal support to the interpretations suggested by DCT. Whilst the observed phenomenon of ‘the concreteness effect,’ for example seems fairly widely supported, its explanation in terms of imageability may not be so universally supported in relatively recent studies. In particular, there are those who have suggested that the observed data reflect not only the imageablity of, for example, a word but also must reflect other semantic dimensions as well. Rodriguez-Ferreiro, Gennari, Davies and Cuetos (2010) discuss some of the semantic representation dimensions noted earlier e.g support for higher activity in the left-lateralized language region for abstract words, a region where verbal codes might be assumed to be processed and on the other hand other studies suggest that activity in some of those regions e.g. left inferior temporal gyrus instead marks for an integrative regulatory or retrieval function. Thus, they suggest that an alternative explanation for the concreteness effect, rather than DCT might be plausible. One explanation they discussed was that maybe abstract words being less imageable than concrete words also require more controlled and what they call ‘grueling’ integration in the brain’s processing networks. Specifically, Rodrigues-Ferreiro et al. (2010) compared neural activity for concrete verbs and abstract verbs (the concrete verbs were categorized into intransitive motion verbs, “to run” and transitive motion verbs, “to wash” and the abstract verbs were categorized into transitive emotion words (“to adore”, “to surprise”) and cognitive verbs (“to think”, “to reason”). Rodrigues-Ferreiro et al. found that concrete verbs compared to pseudo verbs, i.e. fictitious verbs (“to rimd”) revealed several bilateral clusters of activation, such as temporal-occipital, occipital fusiform, precentral and angular gyri and central operculum. These areas are associated with motion and action stimuli in many studies. For abstract verbs, though, compared to pseudo verbs, frontal cortex and temporal cortex were significantly recruited.

These findings were interpreted as indicative of processing of the meaning of the abstract verbs. Thus, the brain seems to process the verb ‘to run’ differently to ‘to adore’ with more reflection/cognition for abstract verbs than for concrete verbs.

In other words, Rodrigues-Ferreiro et al. (2010) suggest that it is not the imageability of words per se that drives the concreteness effect but that it is more to do with the processing of meaning. This could help explain the finding that it may take more time to process abstract words compared with concrete words. There are other studies that also support this notion of the role of meaning (See Bruccino, Colagè, Gobbi, & Bonaccorso, 2016; Galetzka, 2017; Shibahara & Lucero-Wagoner, 2002; Grossman, Koenig, DeVita, Glosser, Alsop, Detre, & Gee, .2002).

All of the above leads to consideration of alternative theories to explain the phenomena related to what has been called the concreteness effect and thus to challenge the whole concept of DCT. Indeed, one line of reasoning claims that there is no concreteness effect whatsoever and offers an alternative interpretation of the data. As far back as 1989, (see Schwanenflugel, & Stowe, 1989; Schwanenflugel, & Noyes, 1996) the Context Availability Model (CAM) was proposed and it suggests that sensory information is not the key to understanding what has been interpreted as a concreteness effect. Rather, they say that the available data reflect the difference in effort required to process different types of material. They claim that the effects reflect the effort to retrieve associative information from prior knowledge. This is reflected, they say, in observations such as the longer processing time required for abstract material. CAM thus differs from DCT in that it does not require the idea of a dual processing system per se but rather emphasizes the role of the relative representational context that surrounds each piece of information to be processed. For example, Schwanenflugel & Noyes (1996) examined the relationship between semantic correlates of word concreteness and lexical processing speed and accuracy in children’s reading, where the participants rate the imageability and context availability i.e. assessed how easy or difficult they experienced the task of thinking about e.g. a given sentence. It was found that context availability rather than imageability affected the results. Thus, CAM suggests that when accessibility of information relating to prior knowledge is controlled for (for example by letting participants rate the accessibility relating to given concrete and abstract stimuli and then using equally rated abstract and concrete material) the abstract words can then be processed just as quickly and accurately as concrete material. CAM represents a body of thought which offers an alternative explanation of the concreteness effect.

Relatedly, neurophysiological studies have demonstrated support for two general types of processing. As reviewed by Kousta, Vigliocco, Vinson, & Del Campo, (2011), there is an N400 component, elicited more strongly by concrete words, for example rather than abstract words. This has been interpreted as being related to a verbal semantic system. A later N700-800 component has been suggested to reflect an imagery -related effect. (for review see see Kutas, Van Petten & Kluender, 2006).

Given that there are these competing views, others have offered a hybrid explanation of the data. For example, Levi-Drori and Henik (2006) (as reported in Gullick, Mitra & Coch, 2013) proposed an Extended Dual Coding Theory (EDT). This EDT supports the idea of a concreteness effect and claims that concrete material has two advantages over abstract material and also maintains some of the attributes of both DCT and CAM. They suggest that there is more ongoing semantic activity for concrete material compared to abstract in a verbal system (analogous to DCT associative processing, perhaps) and an additional contribution of mental imagery for concrete material. Thus, they take into account additional attributes of the material to be processed, over and above imageability. As noted earlier, the Tryon and Bailey (1970) list of attributes separates out concreteness per se and imageability, as well as meaningfulness, familiarity, categorizeability and finally pleasantness.

Thus, it can be seen that an understanding of the differences between processing concrete material and abstract material is rather complicated. Findings from various types of studies vary, not least those from neuroimaging. As noted by Gullick et al. (2013) the role of both stimulus choice and also task demands seem to be of particular importance.

One further stimulus attribute mentioned by Tryon and Bailey (1970) and Toglia and Battig (1978) but which has not been discussed here, so far, is pleasantness. This issue has been addressed in more recent research and will be the focus of the next part of this report. Potentially the role of emotion and the emotional valence of the material to be processed represent a further major challenge to the original formulation of DCT.

Emotion, Dual Coding Theory and Context Availability Model

One of the main challenges to both Dual Coding Theory and Context Availability Model has come from Kousta et al (2011). Although, not the first to argue for a significant role for emotion related aspects of stimuli to be taken into account in formulating theories of mental representation, particularly of linguistic stimuli, the main thrust of Kousta et al.'s (2011) challenge to previous theories was centered on this issue of the role of emotion in e.g. word processing. (See also Altarriba, Bauer, and Benvenuto (1999); Altarriba & Bauer, 2004).

Kousta et al. (2011) claim that the generally accepted assumption that concreteness is somehow synonymous with imageability and responsible for the concreteness effect does not take into account the effect of emotion in e.g. word processing. Kousta et al. (2011) suggest that experiential information i.e. sensory-, motor- and affective information, when processing linguistic information, is used differently for concrete and abstract concepts. Sensory motor information they suggest is predominant for concrete concepts while affective information is suggested to play a greater role for abstract concepts. Indeed, as far back as 1993, Izard suggested there are four interacting systems for emotion activation for cognitive and noncognitive processes, citing neural-, sensorimotor-, affective- and cognitive processes. Both behavioural and neuropsychological studies have been used to support the Kousta et al.'s ideas. The common factor in these studies is that emotion has been included as a possible contributory factor. For example, Palazova, Mantwill, Sommer and Schact (2011) claimed that emotional valence (pleasant or unpleasant charged words) affect at least two Event related potential (ERP) components, an early effect and a later effect. (See also Briesemeister et al., 2014; Fritsch & Kuchinke, 2013; Harmon-Jones, Gable, & Price, 2013; Mneimne & Powers, 2012; Palazova, et al., 2013; Schacht & Sommer, 2009). Furthermore, a study of lexical decision reported by Palazova, Sommer & Schacht (2013) found that overall, lexical decision responses were faster for concrete words than for abstract words. Also, they found that reaction times for neutral words were shorter than for both positive and negative words. The main effect of emotions resulted from decreased reaction times to neutral as compared to both positive and negative words. Further statistical analyses revealed a significant concreteness by emotion interaction. The explanation for this result was found in the abstract conditions where positive as well as negative abstract words were processed more slowly compared to abstract neutral words. For concrete words no effect of emotion was found. ERP amplitudes showed a main effect for concreteness 500m – 800ms post stimulus similar to previously reported effects of concreteness around N700. Further analyses suggested that the relationship between concreteness and emotional content might be indicated by both amplitude and also topography differences. A region of interest analysis at which early posterior negativity was most prominent showed significant effects with emotion for almost all interesting comparisons (P07, P08, P09, P010, and 01, 02) between positively and negatively valenced verbs compared to neutral words for two different intervals 250-300ms and 400-450ms. Thus emotion, considered as a part of semantic information, seems to be processed in the parietal cortex, midline and with concrete verbs no emotion effects were detected. According to the performance data concrete verbs were processed faster than abstract and the early ERP interaction 250-300ms post stimulus replicated the concreteness effect found in some earlier studies.

More recently, using response times in a lexical decision visual task for word recognition, Briesmaster et al. (2014) hypothesized that discrete emotions would be visible in the processing stream earlier than dimensional emotion effects. Specifically, they found that the N1 component appeared around 70 -130 ms.. This component is known to be sensitive to differences in early attentional resources and is suggested to be related to conditional learning. Apparent also were later components such as the early posterior negativity (200-300ms), claimed to relate to word identification and moderated by implicit and automatic processes of affective information; the N400 related to conditioned, emotionally charged, lexico- semantic associations, and the late positive complex at 500---800ms, possibly indicative of higher order evaluative processes i.e. semantic evaluation. They also found that words rated high on happiness were processed faster than words weakly related to happiness and neutral words were processed faster than positive words independently of level of arousal.

Kousta et al. (2011) study mentioned makes the case that neither dual coding theory nor context availability hypothesis account fully for processing differences and hence representational differences between words designated concrete or abstract. Using both experiments and large-scale regression analyses of data from a previously published English Lexicon Project (Balota et al., 2007) Kousta et al. (2011) demonstrated that when a large number of semantic characteristics (cf Tryon & Bailey, 1970 and Toglia & Battig, 1978) are controlled for (including imageability and context availability) there was actually an advantage for *abstract* words over concrete words. In addition, using detailed and sophisticated regression analysis techniques, and a relatively large set of words spanning the entire range of concreteness and, importantly, valence and arousal ratings, they demonstrated that this *abstractness* effect is eliminated when affective associations are taken into account, either by restricting the range of affective factors (Experiment 2) or by taking them into account statistically (Experiment 3).

Kousta et al. (2011) concluded that these insights provide the basis for a different theoretical account of the observed data, namely what they called the embodied view of the semantic representation. Specifically, they conclude (as noted earlier) that both concrete and abstract stimuli hold different types of information, namely sensory-, motor-, affective-, as well as linguistic information. They differ with respect to the relative weight afforded to each of these. Kousta et al. conclude that statistically, sensory- motor information is more likely available and important for representation of concrete words while it is affective information which is statistically more likely available and important for abstract words, with of course linguistic information necessarily available for both and incorporated into most theories of semantic representation. Imaging studies also clearly support such an idea (see Kousta et al. (2011) for a brief review), with abstract/less imageable words, for example being associated with greater left hemisphere language network activation including left inferior frontal gyrus and left superior temporal sulcus. Similarly, Vigliocco et al. (2010) (as cited in Kousta et al., 2011) and more recently, Della Rosa, Catricala, Canini, Vigliocco, and Cappa, (2018) found greater left inferior frontal gyrus activation for abstract over concrete words, and the greater activation in the rostral anterior cingulate cortex found for abstract words and previously linked to emotion was eliminated when valance and arousal were taken into account.

Kousta et al. (2011) also suggest that the previously reported stronger N400 found for concrete words and partially accounted for in terms of meaning (cf Context Availability Model) might not be quite so straightforward. They claim that this observed concreteness N400 differs somewhat from the classical N400 and might be subject to difficulty in retrieving specifically linguistic information for concrete stimuli. Overall, Kousta et al. conclude that, while the traditionally observed concreteness effect is not to be denied, the explanations for it may have been too simplistic by suggesting a single dimension (concreteness/abstractness) as the explanation. Rather, they caution that a more multi dimensional approach is more valid, and give a significant role to the emotional content of the material being processed. It is not necessarily valid to assume that concrete words will have a processing advantage over abstract words. Affective valence, amongst other things, must be given a role.

Paivio (2013) responded to Kousta et al. (2011) and suggested that perhaps Kousta et al. had based their critique of DCT on a rather impoverished version of it. He claimed that DCT was much richer than depicted by Kousta et al., and, if regarded as a broad framework could account for a range of observed data. Furthermore, Paivio suggested that DCT had not actually completely ignored emotional content, but that in 2007 he had suggested that emotional information is part of the non-verbal system and connected to emotion related linguistic information in the verbal system. Vigliocco, Kousta, Vinson, Andrews, & Del Campo, (2013), in response to Paivio’s (2013) response, acknowledge that DCT continued to provide inspiration with regard to semantic representation and processing, but nevertheless reiterated that it could not, in its current formulation, account for Kousta et al.’s abstractness effect. That, they state, requires an approach such as the suggested embodied theory where concrete material is assumed to be more closely associated with external, sensori-motor information and abstract material with internal, affective states.

Given that emotional valence can be assumed to interact significantly with other sensori-motor information such as imageability and also linguistic characteristics of stimuli during processing and mental representation, then it is perhaps of interest to look at another aspect of how emotion affects cognition and ultimately behavior. As noted earlier, Tryon and Bailey (1970) included categorizability as one of the semantic dimensions. This is the extent to which something can be included in a larger group sharing similar features such as dog and cat being members of the group or category ‘pets’. The relationship between categorization, emotion and general aspects of cognition will be the focus of the next section.

Categorization and Affect

As discussed in earlier sections, the role of emotion related things in relation to cognition has perhaps not always been given the attention it deserved. However, in more recent years this neglect has been rectified to some extent with growing interest both at a theoretical and also applied level. The emotional aspects of both the material to be processed cognitively and also the emotional aspects of the individual must be taken into consideration. Given that the various stimulus attributes noted by Tryon and Bailey (1970) have been seen to influence cognitive processes such as memory, reaction times and so on, it would seem reasonable to take this one step further and look at these attributes, including emotion, in relation to how they might interact with each other and specifically, with the individual who is processing the information. Of particular interest is the relationship between the affective state of the participant and categorization of the stimuli. Note that the distinction is being made between the emotion related aspects of the stimuli and the affective state of the participants, such a state being induced either by the attributes of the stimuli themselves or by some other means. Thus, the term ‘emotional valence’ is often used to refer to the intrinsic attributes of a stimulus while ‘induced affect’ or affective state refers to the characteristics of the observer or participant.

As the name suggests, a categorization task is one where participants must place stimuli in different groups according to some selected criterion-based rule. The extent to which an item is included or excluded from a particular group or class can depend on a number of different things and borderline or ambiguous items pose a particular problem. Both the attributes of the stimuli and also various aspects of the participants and the context in which the task is carried out have been suggested to influence the eventual chosen classification for any particular stimulus. Many studies in the area have used an empirical procedure developed by Rosch, (1975) and widely referred to as the Rosch Categorization Task (see also Rosch, Mervis, Gray, Johnson and Boyes-Bream, 1976). In this task, exemplars of various categories of stimuli are presented and classified by participants into the relevant category. The exemplars vary in the extent to which they might be typical of a particular category (strong, moderate, weak exemplars, for example) and their inclusion or exclusion from the class may be dependent upon a number of external factors. One particular line of research has focused on the influence of affect on this categorization task. Specific interest in the impact of affective states on categorization was spearheaded by Isen and Daubman (1984) (See also Gainotto, 2012; Ramon, Doron & Fast, 2007; Rinck & Becker, 2009). Isen and Daubman (1984) demonstrated that participants whose mood had been manipulated to be either positive or negative performed differently in the Rosch task with positive mood being associated with more inclusivity. In other words, an ambiguous category member was more likely to be included in the category by participants with positive induced mood than by participants with negative induced mood or neutral mood state. Isen and Daubman suggested that perhaps this phenomenon could be explained as a kind of implicit tolerance related to a broadening of cognitive scope. This line of research has been developed to include areas such as problem solving, decision making, negotiation, consumer choice, creativity, executive functioning and so on. (see for example, Isen, 2001; Mitchell & Phillips (2007); Nygren, Isen, Taylor & Dulin, 1996; Spassova & Isen, 2013). Furthermore, the role of positive emotions has been developed within the positive psychology framework and the Fredrickson (2001) Broaden and Build Theory relating to broadening of cognitive scope is grounded in Isen's work on categorization. It has been suggested (see for example, Frederickson & Branigan, 2005; Gasper, 2004) that this broadening associated with positivity is related to the use of more flexible, top-down processing and that overall, negative emotions can be shown to be more associated with the use of stimulus characteristics as a basis for processing, encouraging bottom up processes.

Ashby, Isen and Turken (1999) proposed a neuropsychological theory of positive affect and its influence on cognition. Their basic premise was that the dopamine system mediates many (but obviously not all) of the observed phenomena relating to positive affect and that these are intimately related to the reward system. They focus particularly on the nigrostriatal system with its dopamine producing cells in the substantia nigra projecting into the striatum and also on the mesocorticplimbic system with its dopamine producing cells in the ventral tegmental area and projecting to several cortical and limbic areas. Ashby et al. (1999) also consider the possible mechanisms associated with negative mood effects. They caution that the effects of negative mood are probably much more complex and are not mediated in the same way. Specifically, negative effects should not be assumed to be simply the opposite of positive and should not be assumed to be correlated with low levels of dopamine, which is often in fact more closely associated with anhedonia. Mitchell and Phillips (2007) agree with the earlier Ashby et al. proposals and suggest the serotonin system as a plausible candidate, given the evidence that exists in relation to serotonin, the prefrontal cortex and executive function, for example. Mitchell and Phillips (2007) conclude that although dopamine and serotonin may be involved in positive and negative affect effects on cognition, the respective relationships are certainly not linear but more likely u-shaped, the dopamine and serotonin systems may in this regard interact with one another, and these are not the only candidate neurotransmitters. More recently, Ramon, Doron and Faust (2007) examined the interaction between categorization and emotion in terms of hemispheric asymmetry. As they noted, both emotion and categorization had previously been studied independently from a hemispheric point of view, but rarely examined together. The aim of the Ramon et al. study was to examine the relationship between state affect, categorization and hemisphere targeted by the stimuli. They used a split visual fields categorization task of typical and atypical examples of stimulus classes that meant that the role of different hemispheres could be included in the analyses. For example, for the class ‘furniture’, mirror was an atypical exemplar and chair was a typical exemplar. Their finding of a 3-way categorization x visual field x affect interaction they interpreted as support for the idea that positive affect and right visual field left hemisphere resulted in similar speed of processing of both typical and atypical items. For both the negative and neutral affect speed was faster for typical than atypical in both hemispheres. They suggest that the categorization strategy of the left hemisphere is typically abstract, rule-based (and might one suggest possibly linguistic?) and may deal with atypical stimuli more efficiently than the exemplar-based (holistic?) categorization of the right hemisphere. Harmon Jones, Gable and Price (2013) reviewed the general area of positive and negative affect and cognitive scope that has been measured using attention, perception, categorization, word association social categorization, memory and much more. They concluded that, in general, about five decades of research seemed to support the notion that positive broadens and negative narrows cognition. However, they introduce one major caveat. Not all positive affect broadens and not all negative affect narrows cognitive scope. They suggest that, based on research from about 2008 onwards, positive affective states should be subdivided, into those which can be described as low in approach motivation and those that are high in approach motivation. Low approach motivation states would be those brought about after a certain goal has been achieved, such as happiness or gratitude after receiving a gift, for example. Harmon-Jones et al claim that this type is characteristic of a great many of the positive affect inductions used in experimental procedures. Also included in this category of low approach motivation would be those states that are irrelevant to any goal, for example amusement. It is this type of low approach positive affective states that are associated with broadening of cognitive cope. The other class of positive states consists of those that occur most often but (not necessarily) *before* the goal is achieved and are high in approach motivation in that they represent the urge to achieve e.g. desire, enthusiasm. These are sometimes referred to as ‘appetitive states’. These high approach positive affective states are associated with *narrowing* of cognitive scope. There is evidence that high and low positive motivational states can be distinguished at both a neural and neurochemical level and are in part related to reward processing. (see, for example, Berridge, 2007). Harnmon-Jones et al. (2013) report a series of studies covering a five-year period from 2007 which tested these ideas using a variety of experimental techniques, stimulus materials and outcome measures including memory for words and cognitive categorization (cf Isen & Daubman, 1984). In addition, they measured EEG alpha wave activity and found the predicted increased left frontal cortical activity for approach motivation induced by appetitive pictures together with decreased scope of attention. In a different study they found that appetitive stimuli produced larger late positive potentials and narrowing of attention. As far as negative affect is concerned, Harmon-Jones et al. suggest that examination of the literature pre 2008 reports high motivational intensity states such as fear, and few negative low intensity states, such as sadness, despite the fact that some previous work has suggested that e.g. depression may be associated with a broadened cognitive scope. Again, they report a series of studies that manipulated the motivational approach intensity of negative affect by using e.g. pictures which induced disgust (high), sadness (low), and neutral affect. Disgust lead to narrowing of attention and sadness led to increased attentional scope relative to the neutral state. Other studies showed that anger (high approach motivation) resulted in relative narrowing of attentional scope. The interpretation difficulty noted by Harmon-Jones et al. is that the methods used to manipulate motivational intensity might also in some cases have manipulated affective arousal. However, they use amusement as an example to demonstrate how arousal and motivational intensity are not synonomous: amusement is high in arousal but low in approach motivation intensity and is associated with attentional broadening. Interestingly, a more recent study that examined the role of specific emotions in conceptual categorization did not discuss these issues raised by Harmon-Jones et al. (see Zhu, Cai, Sun and Yang-yang (2015).

Rationale for Current Study

Given the foregoing discussion, several general things emerge. Firstly, when other factors are allowed to vary without control, there seems to be a processing advantage for concrete words over abstract words, just as predicted by Dual Coding Theory. Secondly, as demonstrated by for example, Kousta et al. (2011), it may be that emotional valance had a greater influence in the processing of abstract words, and that under some circumstances there may be no concreteness effect and might even be an abstractness effect. This would not be predicted by DCT. Thirdly, as for example Isen and Daubman (1984) have claimed, emotional valence, and particularly positive emotion can influence cognitive processing. Specifically, they demonstrated that positive emotion was associated with more inclusive categorization of ambiguous category members.

This current study is an experimental investigation relating to the above three general points. Firstly, memory for concrete and abstract words will be tested. Secondly, both positively valenced and negatively valenced concrete and abstract words will be included. Thirdly, if the presentation of positively or negatively valenced words induces a congruent mood state in participants, then this should have an effect on participants' performance in a categorization task.

The general predictions were as follows:

1. According to DCT it would be expected that there would be a difference in memory performance between the two general word types, concrete and abstract with a processing advantage for concrete words. H_1: Concrete > Abstract
2. If, however, Kousta et al. (2011) are correct, the concreteness effect may not necessarily emerge in a comparison of emotionally valenced concrete and abstract words. It might however be expected that positive and negative words not be remembered equally well. H_2: Positive ≠ negative.
3. In line with the findings of for example, Isen and Daubman (1984), that positivity produces greater inclusivity, it might be expected that positively valenced abstract words would produce greater inclusivity in a categorization task. H_3: + > −
4. Combining the findings of Kousta et al. (2011) suggesting an abstractness effect with that of Isen and Daubman (1884) suggesting advantage for emotionally valenced abstract words, it might be expected that this would lead to an interaction effect of wordtype and emotional valence on categorization so that participants given positive abstract words would be the most willing to include ambiguous items in the superordinate classes and participants given negative abstract words the least willing to show inclusivity. H_4: $f\,[\,A^{+} \cdot B] > f\,[\,A^{-} \cdot B]$.

2 Method

2.1 Research Design

The experiment was a 2 x 2-between-group, single-blind design, i.e. there were four different experimental conditions. The first independent variable (IV_1): wordtype, was tested at two levels; abstract (A)- and concrete (C)-word level. The second independent variable (IV_2): Word Valence or emotion valence, was tested at two levels; + (positive/pleasant) and – (negative/unpleasant); thus the four experimental conditions were: Abstract positive, Abstract negative, Concrete positive and Concrete negative.(A^+, A^-, C^+ and C^-). There were two dependent variables, recognition memory (DV1) and categorization performance (DV2). Arousal level and gender were controlled for. Confidence ratings for recognition responses were also obtained.

2.2 Participants

A total of 96 participants (52 males, 44 females), with Swedish as their first language, were recruited through personal contact from five different groups: students at the University of Skövde was the largest recruitment group, firefighters from Räddningstjänsten Östra Skaraborg, RÖS, Skövde was the second largest recruitment group, members of Skultorps Ryttarsällskaps Sports Rider’s Association was the third largest recruitment group, employees from Räddningsskolan Skövde AB and former colleagues (Fire Protection Consultants) were the fourth largest recruitment group and finally neighbors and friends. Participants were allocated randomly across the four experimental conditions. Thirteen males and 11 females participated in each experimental condition. Participant ages were 18-25 years-old (53%); 26-35 years (21%); 36-50 years (16%); 51-65 years (7%); and 66 years and older (3%). Participants were not offered any payment, gifts or other rewards for participating and were informed about their rights, at any time, to cancel participation. No one cancelled. No questions about health conditions were asked nor questions about whether the participants were right-or left-handed.

2.3 Stimuli

2.3.1 Recognition test

A total of 64 emotionally valenced adjectives and 32 nouns were picked from the emotional keywords in PANAS-Scale (Watson, Clark, & Tellegen, 1988), from Appendix B, "Emotion Words" in the work of Altarriba et al. (1999) and from Russell (1980).

The 64 adjectives consisted of 32 positively valenced and 32 negatively valenced, with 16 of each category (positive or negtive) either high arousal or low arousal. Sixteen positive and sixteen negative adjectives were used as target items and the remainder as distractor items in the recognition test (see below). These adjectives were used singly as abstract stimuli and co mbined with a noun to form the concrete conditions.The nouns were all referents of either humans or other mammals e.g boy, dog etc. This was to maximize the possibility of achieving 'concreteness' through imageability. The adjective/noun combinations were created randomly to form a unique set for each participant.

As this was a between group design, each group of participants received a different set of stimuli. Abstract positive (adjectives): abstract negative (adjectives); concrete positive (adjective/noun combinations); concrete negative (adjective/noun combinations). Table 1 shows all target words in Swedish and in English.

Table 1. Positive and Negative High and Low Arousal Emotional Adjectives used for Abstract Conditions, i.e. Single-Word Stimuli (translated to English in column one and two), Nouns (randomly used subsequent the emotional adjectives for the concrete conditions in column 3) and Examples of Stimuli for Concrete Conditions in Column 4.

Positive adjectives for A$^+$ group member	**Negative adjectives for A$^-$ group member**	**Nouns**	**Adjective + noun for C$^+$ and C$^-$ groups**
High Arousal	**High Arousal**	**Used subsequently to**	**Example of Stimuli for**
		emotional adjectives	**C$^+$ group member**
Begeistrad/Excited	Bedrövad/Distressed	Baby/Baby	Excited baby
Entusiastisk/Enthusiastic	Fientlig/Hostile	Dotter/Daughter	Enthusiastic mother
Flitig/Diligent	Frustrerad/Frustrated	Flicka/Girl	Calm horse
Inspirerad/Inspired	Ilsken/Angry	Flickvän/Girlfriend	Safe cat
Intresserad/Interested	Nervös/Nervous	Hund/Dog	
Ivrig/Eager	Panikslagen/	Häst/Horse	**Example of Stimuli**
Livlig/Lively	Panic-stricken	Katt/Cat	**for C$^-$ group member**
Uppmärksam/Attentive	Rasande/Furious	Ko/Cow	Frustrated teacher
	Upprörd/Upset	Kollega/Colleague	Nervous dog
		Lärare/Teacher	Ashamed Bboy
Low Arousal	**Low Arousal**	Mamma/Mother	Guilty son
Avslappnad/Relaxed	Bekymrad/Troubled	Pappa/Father	
Fredlig/Peaceful	Modfälld/Crestfallen	Pojke/Boy	
Hoppfull/Hopeful	Nedstämd/Depressed	Pojkvän/Boyfriend	
Lugn/Calm	Ointresserad/	Son/Son	
Nöjd/Content	Uninterested	Vän/Friend	
Tillgiven/Affectionate	Skamsen/Ashamed		
Tillitsfull/Confident	Skeptisk/Skeptical		
Trygg/Safe	Skyldig/Guilty		
	Ångerfull/Regretful		

Table 2. Targets and Distractor Words in Recognition Lists

Pleasant (+) Distractor	**Targets (+)** (English translation in Table 1)	**Unpleasant (-) Distractor**	**Targets (-)** (English translation in Table 1)
Förtjust/Delighted	Begeistrad	Apatisk/Apathetic	Bedrövad
Energisk/Energetic	Entusiastisk	Opålitlig/Unreliable	Fientlig
Angelägen/Keen	Enthustiastic	Otålig/Impatient	Frustrerad
Uppmuntrad/Encouraged	Flitig	Bråkig/Rowdy	Ilsken
Observant/Observant	Inspirerad	Ängslig/Anxious	Nervös
Upprymd/Joyful	Intresserad	Vårdslös/Careless	Panikslagen
Optimistisk/Optimistic	Ivrig	Aggressiv/Aggressive	Rasande
Behärskad/Restrained	Livlig	Missnöjd/Dissatisfied	Upprörd
Fridsam/Tranquil	Uppmärksam	Tanklös/Thoughtless	Bekymrad
Pålitlig/Trustworthy	Avslappnad	Nedslagen/Downcast	Modfälld
Obekymrad/	Fredlig	Pessimistisk/Pessimistic	Nedstämd
Unconcerned	Hoppfull	Oengagerad/	Ointresserad
Stillsam/Sedate	Lugn	Uncommitted	Skamsen
Tålmodig/Patient	Nöjd	Förvirrad/Confused	Skeptisk
Omtänksam/Considerate	Tillgiven	Likgiltig/Indifferent	Skyldig
Harmonisk/Quiet	Tillitsfull	Ansträngd/Strained	Ångerfull
Avspänd/Leisurely	Trygg	Obetänksam/	
		Inconsiderate	

2.3.2 Categorization task

For the categorization task, three superordinate classes were chosen from those used in the original study by Rosch et al (1976). These were furniture, vehicles and clothes. Three strong and six weak basic level items were selected for each class. See Table 3 for details.

Table 3. Categorization Task: Superordinate Classes and Basic Level Items according to same structure as presented by Rosch, Mervis, Gray, Johnson and Boyes-Bream, 1976.

Superordinate Classes	**Möbler/Furniture**	**Fordon/Vehicles**	**Kläder/Clothes**
Basic Level Items	Fåtölj/Armchair	Bil	Kjol/Skirt
Strong Items (SI)	Bord/Table	Cykel	Byxor/Pants
	Köksstol/Chair	Buss	Tröja/Sweater
Basic Level	Vas/Vase	Travsulky/	Skyddsväst/Armo
Weak Items (WI)	Piano/Piano	Trotting Sulky	r
	Spegel/Mirror	Rullstol/Wheelchair	Halsband/Necklac
	Vardagsrumsrums-	Längdskidor/	e
	matta/	Cross Country Skiis	Armbandsur/Wat
	Living Room Carpet	Truck/Electric Trolley	ch
	Vägglampa/Wall	Trehjuling/Tricycle	Slalompjäxor/
	Lamp	Barnvagn/	Slalom Boots
	Tavla/Painting	Baby Carriage	Flytväst/Life
			Jacket
			Handväska/
			Handbag

2.4 Procedure

The precedure consited of three phases: 1. Presentation phases, 2. Recognition memory test and 3. Categorization Task.

Irrespective of experimental condition, each participant was given a folder containing a 16-pages small booklet containing the target words for the presentation phase, a recognition task for the memory test , and the materials for the Categorization Task.

2.4.1 Presentation phase

Participants were instructed to read, silently, the words in the booklet, one page at a time, with 5 seconds allowed for each page. (see Table 1). For the Abstract Positive ($A^{+)}$ group, each page in the 16 -page booklet had one single positive adjective (e.g. enthusiastic): abstract negative group had one negative adjective on each page (e.g. panic-stricken); concrete positive group had a positive adjective-plus a noun on each page (e.g. enthusiastic girl) and finally the concrete negative group had one negative adjective plus a noun on each page (e.g. “panic-stricken girl”). The order of presentation of these stimuli was randomized uniquely for each participant.

2.4.2 Recognition Memory Test

Participants were instucted to indicate whether or not (yes/no response) they had seen the words presented in the recognition test during the presentation phase. Only adjectives were tested. Nouns were not tested. Participants also indicated on a scale of 1-10 how confident they were that each yes/no respnse was correct. There was no time limitation and the recognition test took between five and eleven minutes for participants to perform. Each participant responded to 16 target items and 16 distractor items (see Table 1 and Table 2).

2.4.3 Categorization Task

Following the recognition test, participants carried out the categorization test. They were asked to indicate, on a ten-point-scale, to what extent they considered the given items belonged to the superordinate class (see Table 3.) As described earlier, there were three strong and six weak items for each of three classes (furniture, clothes, vehicles).

No pre- or post-tests about affective state were conducted, since this study was not about mood induction per se, The time to fulfill this task varied between three and eight minutes for participants and there were no regulations for time limitation.

3 Results

Level of significance was set at the 5% level throughout. In order to simplify the presentation of results, generally only statistically significant results are reported. No correction for multiple testing was applied. All data were analyzed using Microsoft SPSS Version 22.

3.1 Recognition Test.

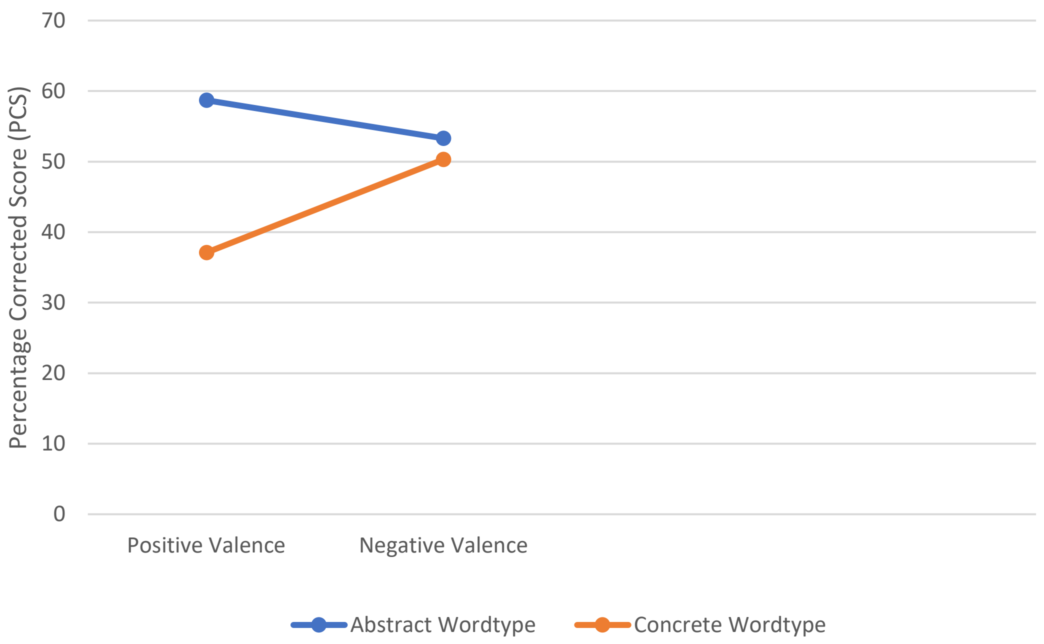
Number of Correct Hits (correct yes response to target items), False Hits (incorrect yes response to distractor items), Correct Misses (correct no response to distractor items) and False Misses (incorrect no response to target items) were computed for each participant. As participants occasionally failed to provide an answer, these raw scores were then converted to percentage scores and denoted Percentage Correct Hits, Percentage False Hits, Percentage Correct Misses and Percentage False Misses. In order to take into account, the possibility of guessing and following the procedure described by Morris, Bransford, and Franks (1977) (cited in Annett & Leslie, 1996), Percentage *Corrected* Scores were then computed. Thus, for DV_1= Percentage Corrected Score = Percentage Correct Hits- Percentage False Hits. The term ‘corrected’ therefore denotes scores which have been adjusted to take into account possible guessing.

Tests of normality for Percentage Corrected Scores were carried out according to Shapiro-Wilk procedure and showed that these Percentage Corrected Scores for all four experimental groups were normally distributed. Similarly, all other distributions were normally distributed apart from Percentage Correct Hits for the Concrete negative group ($p = 0.038$). Given this high level of normally distributed data, it was deemed appropriate to use parametric statistical procedures viz. analysis of variance and t-tests.

Percentage Corrected Scores.

As can be seen in Fig. 1 the Concrete positive group performed worse in the memory recognition task overall (Percentage Corrected Scores) than participants in the other experimental conditions.

Fig 1. Recognition Task: Main Effect of wordtype, Interaction Effect of the wordtype and Emotion Valence on Percentage Corrected Score.



Analysis of variance showed a significant main effect of word type on Percentage Corrected Score [F(1, 95) = 9.39, p = .003] but in the opposite direction than predicted, as Abstract words generated a higher Percentage Corrected Score than Concrete words did for the positive conditions (Abstract words: M = 58,70, SD = 17.63; Concrete words: M = 37.07, SD = 22.96) as well as for the negative conditions (Abstract words: 53,28, SD = 20,45; Concrete words: M = 50.30, SD = 17.08). The percentage corrected score for the abstract positive condition was statistically significantly higher than that for the concrete positive condition ($t = 3.66$, $p = 0.001$). There was no main effect of emotional valence on Percentage Corrected Score but there was a significant interaction effect between word type and emotional valence on Percentage Corrected Score. [$F(1, 95) = 5.39$, $p = .022$].

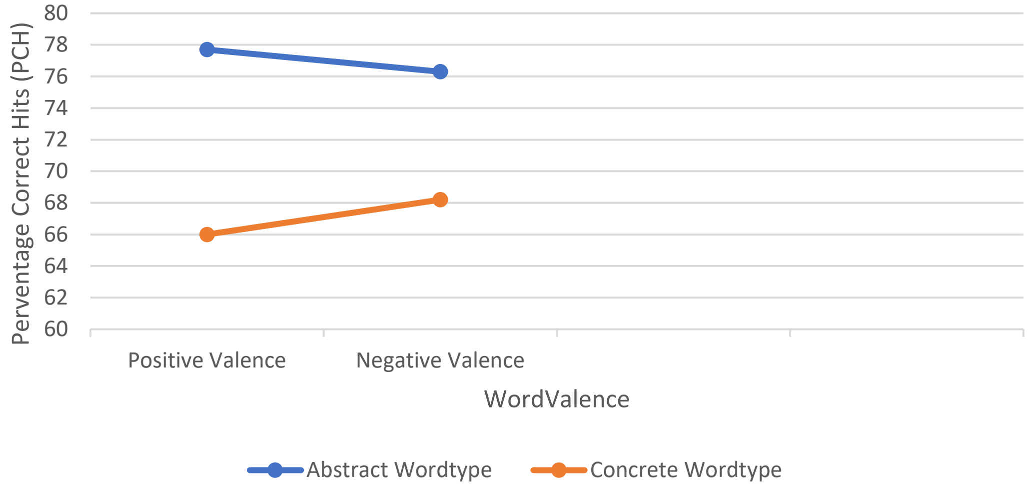
Since there was a significant main effect of word type on Percentage Corrected Score analysis across the four different response classes separately was conducted (Correct Hits, False Hits, Correct Miss, False Miss) in order to investigate further the source of the pattern of responding.

Percentage Correct Hits:

ANOVA showed a significant main effect of word type on Percentage Correct Hits [$F(1, 95) = 14.33$, $p < .001$]. Abstract words generated statistically significantly higher Percentage Correct Hits than Concrete words did for the positive condition (Abstract Words: M = 77.72, SD = 12.30; Concrete Words: M = 65.98, SD = 13.31: $t = 3.17$ $p = 0.003$), as well as for the negative condition (Abstract Words: 76.25, SD = 14.31; Concrete Words: M = 68.24, SD = 10.96: $t = 2.18$, $p = 0.035$).). There was no main effect of emotion valence and no interaction effect.

ANOVA showed, thus, a significant effect for word type on Percentage Correct Hits where participants in Abstract positive and Abstract negative groups, in the opposite direction to that predicted, performed better than participants in the Concrete positive and Concrete negative groups did (see Figure 2).

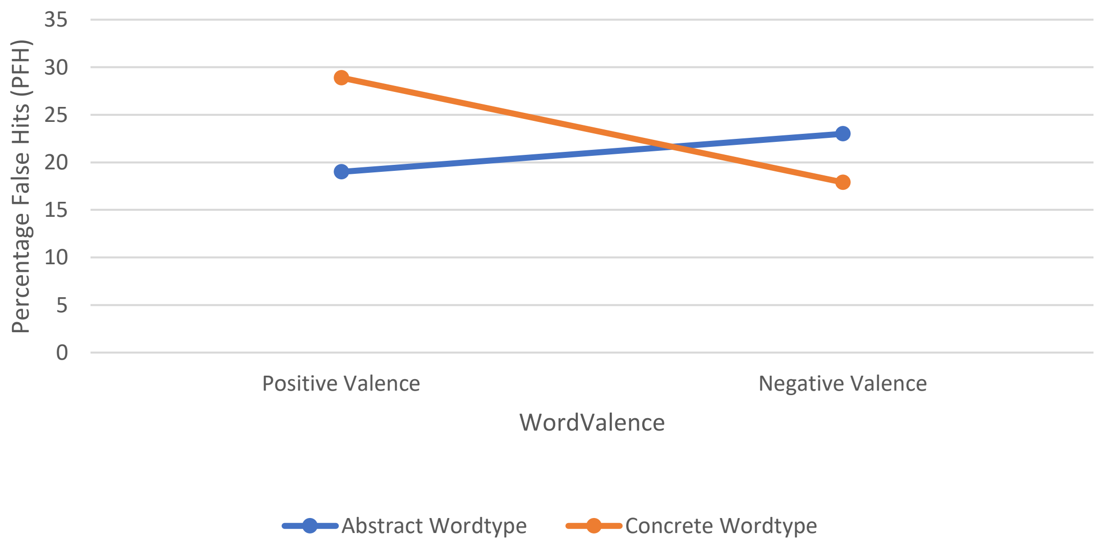
Fig 2. Main Effect of Wordtype on Percentage Correct Hits (PCH)



Percentage False Hits:

ANOVA showed no main effect of word type and no main effect of emotion valence on Percentage False Hits. However, there was a significant interaction effect of word type and emotional valence on Percentage False Hits [F(1, 95) = 7.51, p = .007], as shown in Fig. 3,

Fig 3. Significant Interaction Effect of Wordtype and Emotion Valence for Percentage False Hits (PFH)



There was a significant difference in Percentage False Hits between Concrete positive (M = 28.90, SD = 16.97) and Concrete negative (M = 17.93, SD = 10.73) groups [t (46) = 2,676, p

= .011] but no significant difference between Abstract positive (M = 19.01, SD = 12.26) and Abstract negative (M= 22.98, SD = 12.58) groups. The concrete positive condition produced significantly higher percentage of False Hits than the abstract positive condition (t = 2.13, p = 0.025).

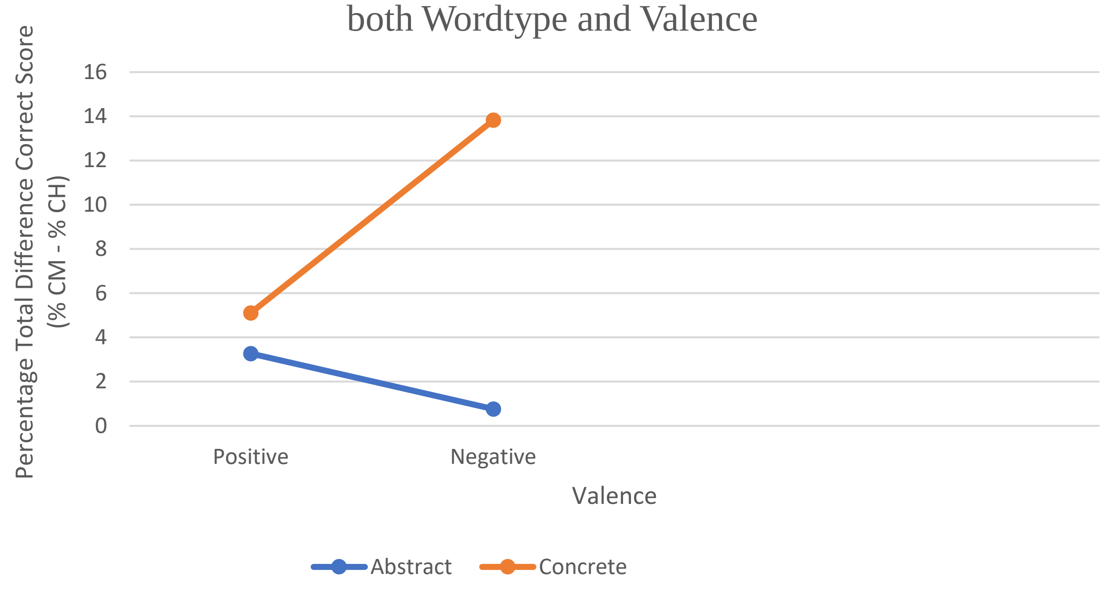
Percentage Total Difference Correct Score (Percentage Correct Miss – Percentage Correct Hits)

Thus, there was a significant main effect of word type on Percentage False Hits but no significant difference between the two levels within each of the two word-type-groups, Abstract and Concrete. There was also a significant interaction effect of word type and emotion valence on Percentage False Hits where there was a difference between Concrete positive and Concrete negative groups. Therefore, it was interesting to examine the difference between Abstract and Concrete groups from another perspective. Therefore, a further variable, Percentage Total Difference Correct Score was computed by subtraction of Percentage Correct Hits from Percentage Correct Miss (see Figure 4).

Analysis of variance showed a significant effect of word type on Percentage Total Difference Correct Score [F(1, 95) = 4.50, p = .037] as overall, Percentage Total Difference Correct Score for the combined Concrete conditions (M = 9.47, SD = 2. 48), was higher than percentage Total Difference Correct Score for the combined Abstract conditions (M = 2.01, SD = 2.48).

Pairwise comparisons across all four conditions showed that the Concrete negative condition (M = 13.82, SD = 13.37) had statistically significantly higher Percentage Total Difference Correct Scores than the Abstract negative condition (M = 0.76, SD= 17.56) (t = 2.89, p = 0.006). The comparison between Concrete positive (M = 5.11, SD = 20.08) and Concrete negative conditions although statistically non-significant, showed a trend toward significance (p = 0.08).

Fig. 4 Means for Percentage CM minus Percentage CH for both Wordtype and Valence



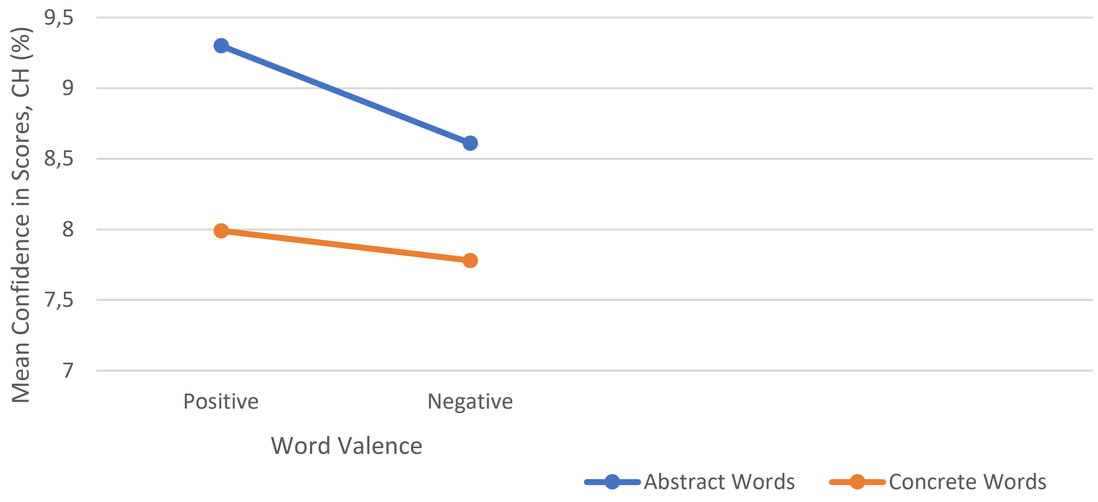
Thus, overall the Abstract conditions performed better than the Concrete conditions when assessed by Percentage Corrected score., contrary to what would normally be expected if a concreteness effect were present. The Concrete positive group performed unusually poorly when assessed using the Percentage Corrected Score (Fig. 1) and tended towards an advantage for Percentage Correct Miss scoring over Percentage Correct Hits scoring, pointing to an unusual response pattern for participants in the Concrete positive condition.

Confidence Ratings

Confidence ratings of recognition responses were included as a proxy measure of implicit processing. A similar analysis strategy was applied to these confidence ratings as applied above to the recognition responses. Mean confidence ratings are presented for each type of answer; Correct "yes" ("yes" for targets i.e. Correct Hits), Incorrect "yes" ("yes" for distractors, False Hits), Correct "no" ("no" for distractors, Correct Miss) and Incorrect "no" ("no" for targets, False Miss). Mean confidence for each category of response was computed for each participant.

Confidence Correct Hits.

Fig. 5 Main effect of Wordtype on Average Confidence in Correct Hits



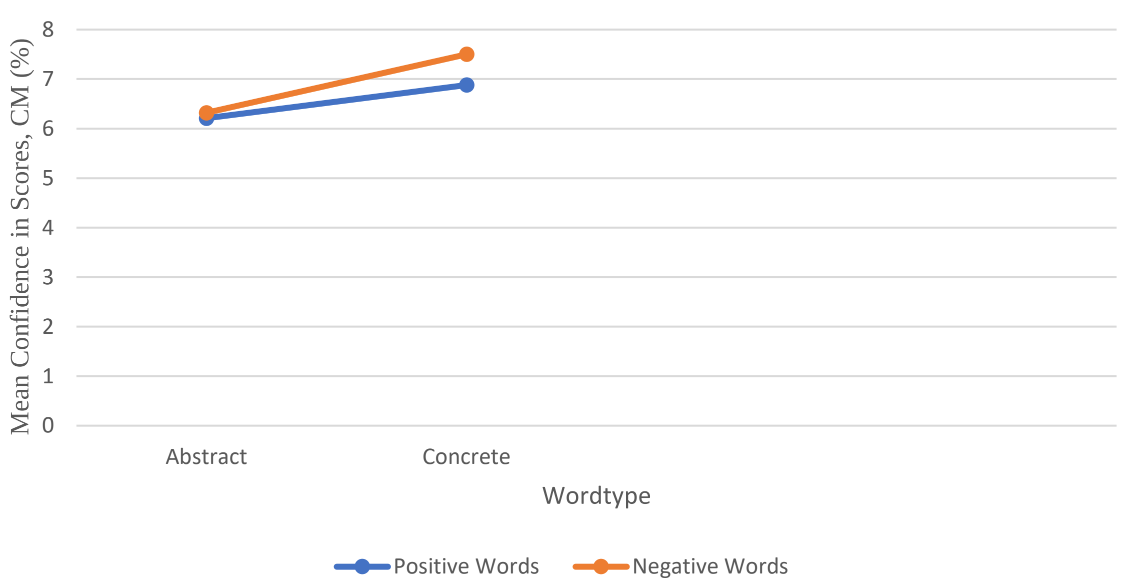
ANOVA showed a significant main effect of word type on Average Confidence Correct Hit Score [F(1, 95) = 4.98, p = .028] as Abstract words generated higher Average Confidence Correct Hit Scores than Concrete words did for the positive condition (Abstract words: M = 9.30, SD = 3.99; Concrete words: M = 7.99, SD = 1.33) as well as for the negative condition (Abstract words: M = 8.61, SD = 1.15; Concrete words: M = 7.78, SD = 1.77). This result is consistent with the fact that participants in the Concrete positive group, who performed unexpectedly weakly, compared to the other three experimental groups, also were the ones low in their confidence ratings as were also Concrete negative. Neither a main effect of emotional valence nor an interaction between word type and emotion valence on Average Confidence Correct Hits were found.

Confidence Correct Miss

A significant main effect of valence on Average Confidence Correct Miss [F(1, 94) = 4.84, p = .030] was found, as negative words generated higher Average Confidence Correct Miss Scores than positive words did for the Abstract condition (positive : M = 6.21, SD = 2.50; negative : M = 6.88, SD = 2.01) as well as for the concrete condition (positive : M = 6.32, SD = 1.80; negative: M = 7.50, SD = 1.83). Thus, participants induced with unpleasant emotion words scored higher on their Confidence on Correct “no”-answers, i.e. they were more certain than participants induced with pleasant emotion words that they had not seen the distractor words

during the presentation phase of the procedure. (-) > (+) as shown in Fig 6.

Fig 6. Main Effect of Valence on Average Confidence for Correct Misses (CM



Confidence False Hits.

Average confidence in False Hits responses were highest for the Abstract negative condition (M = 6.74, SD = 2.01), followed by Concrete positive (M = 6.57, SD = 1.87), Abstract positive (M = 6.47, SD = 2.32) and Concrete negative (M = 5.57, SD = 2.23). However, these scores did not differ very much, apart from the Concrete negative condition being slightly lower than the others. There were no significant main effects or interaction.

Confidence False Miss.

Average confidence for False Miss responses decreased in the order Concrete negative (M = 6.51, SD = 2.35), Abstract positive, (M = 6.27, SD = 3.80), Concrete positive (M = 6.06, SD

= 1.88), Abstract negative (M = 5.74, SD = 2.3), with the differences between all four conditions being small. There were no statistically significant main effects for Word type or for Valence and no interaction.

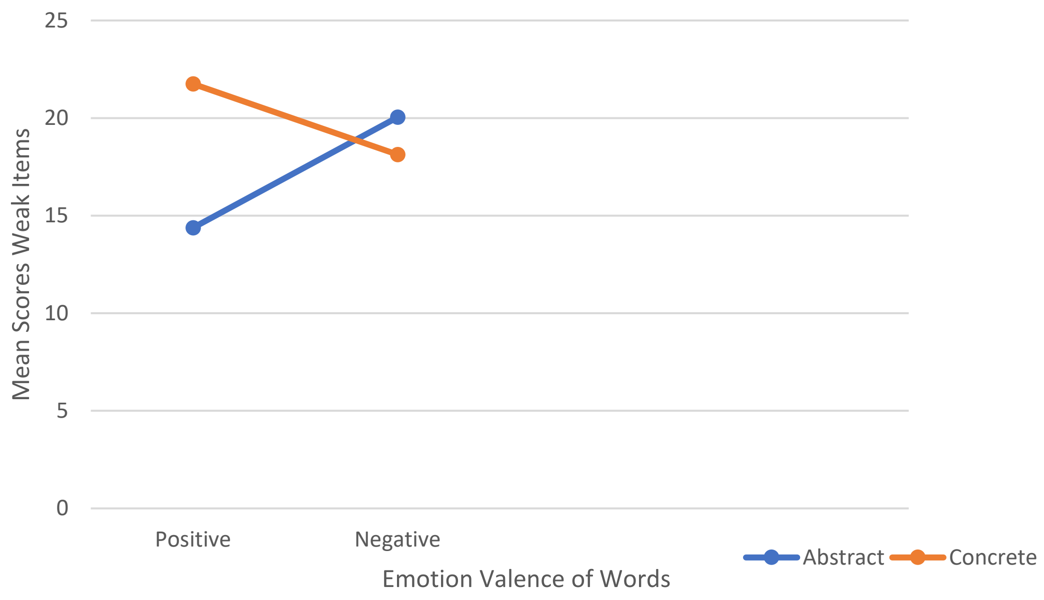
3.2 Categorization Task

Total ratings were computed for each participant for the weak items of the categories Furniture and Clothes. Due to an error in administration of the test, responses for the 'vehicles' category could not be analyzed. Ratings for the strong items were not analyzed as these were included mainly as filler items and to provide a reference point for participants. In fact, all strong items for furniture and clothes were rated 10 by all participants who responded.

Categorization of Furniture, Weak Items

Total Categorization scores for the weak furniture items for the four experimental conditions decreased in the order Concrete positive (M = 21.75, SD = 12.1), Abstract negative (M = 20.04, SD = 11.39), Concrete negative (M = 18.13, SD = 11.01), Abstract positive (M = 14.38, SD = 8.09). Analysis of variance showed no statistically significant main effect of either word type or of emotional valence on participants' ratings of Furniture Weak Items. However, there was a significant interaction effect [F(1, 95) = 4.46 p = .037] as presented in Figure 7. The difference between the Abstract positive and Abstract negative conditions was marginally significant (t =1.98, p = 0.053) and the difference between Abstract positive and Concrete positive was statistically significant (t = 2.47, p= .017). This means that the *predicted* interaction effect, however, was different from these findings since predictions were made that participants in the Abstract word conditions would include and exclude the most, i.e. A^+ members were predicted to get the highest including scores and A^- members were predicted to get the lowest including scores due to Kousta et al.' s (2011) suggestion that affective information is more important for Abstract word processing compared to Concrete word processing.

Fig. 7 Categorization, Furniture, Weak Iteams
Interaction Effect of Wordtype and Emotion Valence on Scores for Weak Items

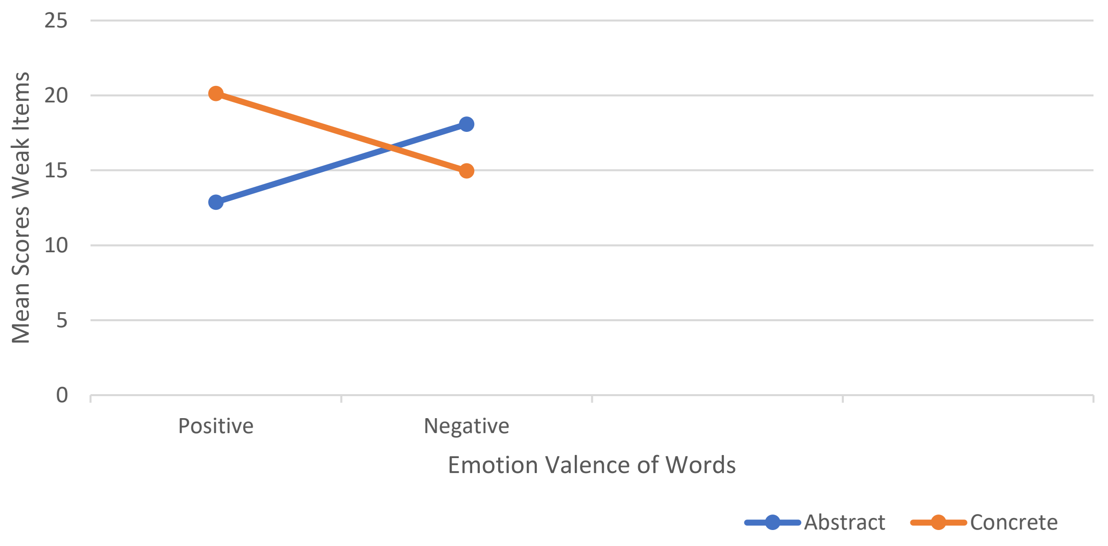


Categorization of Clothes, Weak Items

As presented in Fig 8. the same pattern of responding was repeated for the weak items in the superordinate class, “clothes”, as for “furniture”.

There was a significant interaction effect [F(1, 95) = 5.96, p = .016] and Abstract positive scores (M = 12.88, SD = 9.22) were significantly lower than Concrete positive (M = 20.17, SD = 14.35).

Fig. 8. Categorization, Clothes, Weak Items
Interaction Effect of Wordtype and Emotion Valence on Scores for Weak Items



The result for this superordinate class “clothes”, was repeated also for main effects, i.e. there was, like the “furniture”-classification-task, neither a main effect of word type nor of emotional valence on rating of weak items. This unexpected outcome is discussed further, from a research design perspective, in the Discussion Section.

4 Discussion

The current experimental study was conducted to examine the role of affective information on the processing of abstract and concrete words and subsequent recognition memory, together with possible effects on categorization. As described earlier, the main theoretical ideas stem from Dual Coding Theory (e.g. Paivio, 1991), Context Availability Theory (e.g. Schwanenflugel, & Stowe, 1989; Schwanenflugel, & Noyes, 1996) and other hybrid accounts which highlight the role of emotional valence (e.g. Kousta et al., 2011). Neuroimaging studies support the idea of different neural representation patterns for processing abstract and concrete material. For example, the meta-analysis presented by Wang et al. (2010) suggests stronger activation in the left precuneus, parahippocampal gyrus, posterior cingulate and fusiform gyrus for concrete material while abstract information shows stronger activation in the inferior frontal gyrus and in the middle temporal gyrus in the left hemisphere. However, as noted earlier, this meta-analysis could be interpreted as providing some support for both Paivio's Dual Coding Theory and for Kousta et al.'s alternative suggestions.

According to Dual Coding Theory there should be a memory advantage for concrete words compared to abstract words through activation of both the verbal-linguistic system and the non-verbal imagery system by the concrete words. In the current study both concrete and abstract words of both positive and negative valence were used as target stimuli for a recognition test. As Kousta et al. (2011) suggested, that word processing might involve at least four different networks (sensory, motor, affective and linguistic), including emotional valence as a variable was to try to evoke potential implicit processes that might influence memory (cf Kousta et al.) and also categorization (cf Isen and Daubman, 1984).

The first hypothesis was that there would be a difference in memory for the two types of words, concrete and abstract. There was a significant effect for word type and the null hypothesis was rejected, i.e. there was a difference between the participants' performance in the recognition task depending on word type. However, this effect was in the opposite direction to what would be predicted by Dual Coding Theory. That is, overall, memory for abstract words was better than memory for concrete words. This does not support the concreteness effect predicted by Dual coding theory but could be interpreted as support for an abstractness effect proposed by. Kousta et al. It is not claimed, though, that this finding supports Kousta et al' s. (2011) hypothesis about the role of affective information. This is because the interaction effect between word type and valence complicates interpretation of the result. Note that the second hypothesis was that there might be an effect on memory of word valence, but the direction was not predicted (H_2: $+ \neq -$.) It was actually found that there was no main effect for valence thus that null hypothesis was retained.

Briesmaster et al (2014) discussed the possibility of early posterior negativity potential as a marker for word identification, moderated by implicit and automatic processes of affective information. One speculative idea might be that, since this current experiment was conducted within a different (longer) time frame compared to standard event related potential studies perhaps cognitive evaluation might have had a significant influence on the results. As noted in the Introduction, Izard (1993) suggested that there are four systems involved in evoking emotional effects: neural, sensorimotor, affective and cognitive processes. The problem is to interpret which of these might have greatest influence. Even given the possibility that affective processes dominate and combining this with the possibility that Kousta et al. are correct in relation to the differences between concrete and abstract material per se, this does not explain why concrete positive participants performed worse than concrete negative participants in the recognition task. Remember that in order to ensure a clear distinction between abstractness and concreteness, nouns were combined with the positive and negative adjectives to form the concrete stimuli. This could actually have turned out to be a research design fault by introducing a more ‘cognitive’ component to the concrete stimuli. However, it is puzzling that this double-word effect was not manifest in the concrete negative condition. They should, all other things being equal, have been affected in the same way as the concrete positive participants but they were not. Thus, what does this interaction between valence and word type really mean? Why did the positive concrete group perform less well than expected? Perhaps it was confusing for participants in the concrete words conditions when they encountered only the adjective words in the recognition task, not combined with the nouns which they had seen during the presentation phase (silent reading). The idea of combining adjectives and nouns was to enhance the concreteness and possibly imagery components. Maybe other attributes were also unintentionally influenced, such as number of attributes or meaning (cf Tryon & Bailey, 1970 and Toglia, & Battig, 1978) thus introducing significant confounding factors rendering comparison of concrete with abstract invalid. Besides, many published studies have used verbs or nouns, and not adjectives.

Palazova et al. (2011) in their ERP-study found that reaction times were shorter both for positive and negative words compared to neutral words and additionally shorter for positive than negative words. Additionally, they found a main effect on word class, where the shortest reaction times were for nouns. Main effects of emotion were observed between 300 and 550 ms. For adjectives and verbs, a second emotion effect in ERPs occurred between 400 and 550 ms. In nouns, only, EPN-like emotion effects occurred but no LPC-like emotion effect. If positive words are processed faster than negative words in ERP-studies, and nouns gave no LPCs while adjectives gave a second emotion effect, i.e. no higher order semantic evaluation of nouns, could that early difference in milliseconds, between negative and positive valence of words, have an impact on subsequent implicit processes? Does it matter? What happens when positive adjectives are combined with nouns compared to the combination of negative adjectives with nouns? Could these early processes evoke subsequent unconscious conflicting processes that could last long enough to influence memory even minutes later? Thus, are the early emotion conditioned potentials capable of evoking implicit subsequent processes that could matter even in a time scale of minutes?

The literature suggests that there is a kind of asymmetrical processing where the left- and right brain hemispheres are responsible for several types of word-processing. Many factors seem to influence the results in word-processing studies. Grammatical form of words impacts; motion verbs show different neural activity compared to abstract verbs. Positive valence words sometimes are processed faster than negative valence words, but not always.

The activity in the left-lateralized regions, e.g. left inferior frontal gyrus, is suggested to mark for an integrative, regulatory or retrieval function according to Rodriguez-Ferreiro et al. (2010). So therefore, the differential neural activity for abstract and concrete words in these brain regions could be explained by difference in retrieval processes. One explanation for that, discussed by Rodriguez-Ferreiro et al. (2010) is that abstract words are assumed to be less imageable than concrete words and therefore require more controlled and grueling integration in the brain's processing networks. So why, then, was the abstract positive group the least willing group to include weak items in the categorization tasks? Other studies suggest that there is a hemispherical difference in word-processing where the left inferior frontal gyrus is suggested to activate when processing abstract words. However, the literature is somewhat inconsistent. (Rodriguez- Ferreiro et al., 2010).

Of further interest in relation to the confidence ratings and connected to Isen and Daubman (1984) and Fredrickson (2001) and the Broaden and Build Theory, is the fact that participants who were presented with negative emotion words had higher confidence in correct "No" responses for distractors than those given positive words. Is it possible that participants induced with positive words might have broadened their cognitive scope so that they were affected in their confidence on distractor words, using more reflective processing systems when solving the task? "Maybe I saw this word in the booklet, after all...?". The analysis of recognition performance for the four possible response types separately (Correct Hits, False Hits, Correct Misses, False Misses) showed that there was a significant difference between the positive and negative concrete groups but no significant difference in false hits between the abstract groups, contributing to the overall weak performance in the concrete positive group. In other words, they were more willing to accept distractors as targets during the recognition test, which could possibly indicate more inclusivity.

One variable that has not been investigated in this study is whether there was any difference in time used to fulfill the recognition task between pleasant- and unpleasant-word-induced participants. One suggestion is, since positive concrete group members were more willing to include distractors as targets, that they spent more time reflecting about possibilities to include words as targets. Perhaps future replication could examine, or limit time spent to complete the recognition task.

The third and fourth hypotheses were centered on the categorization task. The predicted overall effect of increased inclusivity for positive words was not found, nor the expected greater inclusivity associated with abstract words. Recall that according to Kousta et al.'s (2011) suggestion of an abstractness effect related to greater influence of valence on abstract material, it was expected that implicit valence related processing would lead to an interaction effect of word type with valence on categorization so that Abstract positive participants should have been most willing to include ambiguous items and Abstract negative participants least willing. The opposite finding is difficult to explain. The fact that it was a positive condition that produced greatest inclusivity fits with Isen and Duabman (1984) and Fredrickson (2001) but it is nevertheless puzzling why the abstract positive condition was less inclusive. Perhaps it would have been better to have placed the categorization task before the memory task so that any induced effects of valence might have been more stable.

Final Summary:

The aim of this study was to examine the effects of word type and valence on recognition memory and categorization. Different theories about word-processing seem to agree that the human brain does process concrete words differently from abstract words. The two dominating word-processing theories, DCT and CAM are opponents, though. The DCT suggests a concreteness effect favoring concrete word-processing, in processing speed and in memory performance and explains the concrete advantage in terms of different degrees of difficulty referring to imageability for abstract and concrete words. CAM does not reject the concreteness effect but does reject the imageability explanation. CAM instead explains the concreteness effect in terms of associated-semantic-information-difference between concrete and abstract words. CAM suggests that after controlling for context availability, prior knowledge and experience of a word, there are no differences between abstract and concrete word-processing. Thus, the concreteness effect is explained from different demands on retrieval processes, suggesting an explanation in different neocortical extensive activity. Children learn nouns before they learn adjectives; a dog, a table, a tree, a book are words children learn early in life, while abstract words are learned later. Thus, the context availability, for a child, is lower for a word like “useful” compared to “dog”. Kousta et al. (2011) in turn, reject the concreteness effect and claim that there is an abstractness advantage Recent ERP-Studies (Briesemeister et al., 2014) suggest support for emotional conditioned early attention and emotional conditioned lexico-semantic processing, both automatic and unconscious components, being to be involved in word-processing. Furthermore, several semantic representation components are involved in word processing (Toglia and Battig, 1978) which is one explanaton for inconsistency in results in word-processing studies through decades.

Neuroscientific studies e.g. Rodriguez-Ferreiro et al. (2010), suggest that the human brain seems to process motion verbs e.g. “run” differently from abstract words like “adore”, where reflection-and cognition processes are suggested to be activated more frequently for abstract verbs than for concrete verbs, meaning quicker processing of concrete words, consistent with the concreteness effect suggested in the DCT (Paivio, 1991). Hernandez, Woods, and Bradley (2015) concluded that words, more generally, not distinguishing abstract from concrete words, are processed mainly in the left hemisphere which is consistent with the theories of verbal, linguistic processing system in the lateralized left hemisphere. Hung et al. (2015) suggested that the left inferior frontal gyrus supports a general mechanism underlying structural building in the language domain. Dual Coding Theory (Paivio, 1991) suggests a processing advantage for concrete words, including faster processing and memory advantages compared to abstract words because of two different brain processing systems; the somatosensory cortical neural system and the verbal linguistic system in the left lateralized hemisphere.

The results of this current study did not support the concreteness effect suggested in the DCT since there was a main effect of word type, with advantage for abstract group members in performance of the recognition task. This could be an indication of support for the hypothesis of Kousta et al. (2011) but great care must be taken when interpreting these results. There are other plausible explanations, including the influence of valence on broadening of cognitive scope.

Acknowledgements

First, I want to thank my supervisor, Judith Annett, Visiting Professor, School of Bioscience, Department of Cognitive neuroscience and philosophy University of Skövde for her serious and responsible support in conducting this study. Professor Annett has been of invaluable help to me in terms of being helpful and seriously interested in all parts of current study, from formulating my research question, structuring the introduction for a, to say the least, extensive literature in chosen topic, determination of research design, choice of methods, advice in the experimental phase and choice of statistical analyses. Professor Annett has shown a great interest in supervising me as an undergraduate student and she has, in a committed way, been helpful to me when performing my first experimental study in life. Second, I want to thank all participants who made this study possible; students at the University of Skövde, Räddningstjänsten Östra Skaraborg, Räddningsskolan Skövde AB, former colleauges, i.e. Fire Protection Engineers working as Fire Protection Consultants for various private companies, Skultorps Ryttarsällskap and all other people who have participated, including friends and neighbors. Finally, I want to thank all lecturers during these four years where I have been studying cognitive neuroscience, focusing on applied positive psychology and been working with this experimental study. I appreciate an interesting content and teaching lecturer’s approach to the students. Especially, in addition to professor Annett, I want to mention Daniel Broman, Lecturer in Cognitive Neuroscience, School of Bioscience, Department of Cognitive neuroscience and philosophy University of Skövde, for his valuable and inspiring lectures in the subject Statistics. Broman has been a major help to me as well, in so many ways, in order to complete this work. Thank you, both of you.

References

Altarriba, J., & Bauer, L. M. (2004). The distinctiveness of emotion concepts: A comparisonbetween emotion, abstract, and concrete words. *American Journal of Psychology, 117,* 389-410.

Altarriba, J., Bauer, L. M., & Benvenuto, C. (1999). Concreteness, contextavailability, and imageability ratings and word associations for abstract, concrete, and emotion words. *Behavior Research Methods, Instruments, & Computers, 31*(4), 578-602.

Anderson, J. R., & Bower, G. H. (1974). A propositional theory of recognition memory. *Memory & Cognition, 2*(3), 406-412.

Annett, J. M., & Leslie, J. C. (1996). Effects of visual and verbal interference tasks on olfactory memory: The role of task complexity. *British Journal of Psychology, 87*, 447-460.

Ashby, F. G., Isen, A. M., & Turken, U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*(3), 529-550.

Baddeley, A. D. (1986). *Working memory*. Oxford, UK: Oxford Univ. Press.

Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation, 8*, 47-89.

Baddeley, A. D., & Hitch, G. (1994). Developments in the concept of working memory. *Neuropsychology*, *8*(4), 485-493.

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. I., Kessler, B., Loftis, B., . . . Treiman, R. (2007). The English Lexicon Project. *Behavior Research Methods, 39*, 445-459.

Berridge, K. C. (2007). The debate over dopamine's role in reward: the case for incentive salience. *Psychopharmacology, 191*, 391-431.

Binder, J. R., Westbury, C. P., McKiernan, K. A., Possing, E. T., & Medler. (2005). Distinct brain systems for processing concrete and abstract words. *Journal of Cognitive Neuroscience, 17,* 905-917.

Bleasdale, F. A. (1987). Concreteness-dependent associative priming: separate lexical organization for concrete and abstract words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*, 582-594.

Briesemeister, B. B., Kuchinke, L., & Jacobs, A. M. (2014). Emotion word recognition: discrete information effect first, continuous later? *Brain Research, 1564*, 62-71.

Bruccino, G., Colagè, I., Gobbi, N., & Bonaccorso, G. (2016). Grounding meaning in experience: A broad perspective on embodied language. *Neuroscience and Biobehavioral Reviews, 69*, 69-78.

Clark, J. M., Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review, 3*(3), 149-210.

Clark, J. M., Paivio A. (1987). A dual coding perspective on encoding processes. In M. A. McDaniel, & M. Pressley (Eds.), *Imagery and related mnemonic processes* (pp. 5-33). New York, NJ: Springer.

de Groot, A. M. (1989). Representational aspects of word imageability and word frequency as assessed through word association. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 824-845.

de Groot, A. M. B., Keijzer, R., (2000). What is hard to learn is easy to forget: the roles of word concreteness, cognate status, and word frequency in foreign-language vocabulary learning and forgetting. *Lang. Learn.* 50, 1–56.

Della Rosa, P. A., Catrica E., Canini. M., Vigliocco, G., &, Cappa, S.F., (2018). The left inferior frontal gyrus: A neural crossroads between abstract and concrete knowledge. *Neuroimage*, 175, 449- 459.

Fliessbach, K., Weis, S., Klaver, P., Elger, C. E., & Weber, B. (2006). The effect of word concreteness on recognition memory. *NeuroImage, 32*, 1413–1421.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and build theory of positive emotions. *American Psychologist 56*, 218-226.

Fredrickson, B. L., & Braningan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion, 19*(3), 313-332.

Fritsch, N. K., & Kuchinke, L. (2013). Acquired affective associations induce emotion effects in word recognition: an ERP study. *Brain and Language, 124*(1), 75-83.

Gainotto, G. (2012). Unconscious processing of emotions and the right hemisphere. *Neuropsychologia, 50*, 205-218.

Galetzka, C., (2017). The story so far: how embodied cognition advances our understanding of meaning-making. Frontiers in Psychology, *8*, 1-5.

Gasper, K. (2004). Permission to Seek Freely? The effect of happy and sad moods on generating old and new ideas. *Creativity Research Journal, 16*(2-3), 215-229.

Grossman, M., Koenig, P., DeVita, C., Glosser, G., Alsop, D., Detre, J., & Gee, J. (2002). Neural representation of verb meaning: an fMRI study. *Human Brain Mapping, 15*, 124-134.

Gullick, M., M, Mitra, P., & Coch, D. (2013). Imagining the truth and the moon: an electrophysiological study of abstract and concrete word processing.*Psychophysiology 50,* 431-440.

Harmon-Jones, E., Gable, P. A., & Price, T. F. (2013, August). Does negative affect always narrow and positive affect always broaden the mind? Considering the influence of motivational intensity on cognitive scope. *Current Directions in Psychological Science*, 1-23.

Hernandez, A. E, Woods, E. A, & Bradley, K. A. (2015). Neural correlates of single word reading in bilingual children and adults. *143*, 11-19.

Hiroshi, N., Suehiro, M., & Hori, T. (2002). Word imageability and N400 in an incidental memory paradigm. *Int. J. Psychophysiol, 44,* 219–229.

Howell, J. R., & Bryden, M. P. (1987). The effects of word orientation and imageability on visual half-field presentations with a lexical decision task. *Neuropsychologia, 25,* 527–538.

Hung, U. H., Pallier, C., Dehaene, S., Lin, Y. C., Chang, A., Tzeng, O. J., & Wu, D. H. (2015). Neural correlates of merging number words. *NeuroImage, 122*, 33-43.

Isen, A. M. (2000). Some perspectives on positive affect and self-regulation. *Psychological Inquiry, 11*(3), 184-187.

Isen, A. M. (2001). An influence of positive affect on decision making in complex situations: theoretical issues with practical implications. *Journal of Consumer Psychology, 11*(2), 75–85.

Isen, A. M., & Daubman, K. A. (1984). The influence of affect on categorization. *Journal of Personality and Social Psychology, 47*, 1206-1217.

Izard, C. E. (1993). Four systems for emotion activation: cognitive and noncognitive processes. *Psychological Review, 100*(1), 68-90.

Kosslyn, S. M. (1980). *Images and mind*. Cambridge. MA: Harvard University Press.

Kosslyn, S. M. (1981). The medium and the message in mental imagery: a theory. *Psychological Review, 88*, 46-66.

Kousta, S. T., Vigliocco, G., Vinson, D. P., & Del Campo, E. (2011). The representation of abstract words: why emotion matters. *Journal of Experimental Psychology: General, 140*(1), 14-34.

Kroll, J., & Merves, J. S. (1986). Lexical access for concrete and abstract words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12,* 92-107.

Kutas, M., Van Petten, C., & Kluender, R. (2006). Psycholinguistics electrified II: 1994-2005.

In M. Traxler, & M. A. Gernsbacher (Eds.), *Handbook of psycholinguistics* (pp. 659-724). New York, NY: Elsevier.

Ma, W., Golinkoff, R. M., Hirsh-Pasek, K., McDonough, C., Tardif, T. (2009). Imageability predicts the age of acquisition of verbs in Chinese children. *J. Child. Lang. 36,* 405-423.

Madigan. S. (1983). Picture memory. In J.C. Yuille (Ed.), *Imagery, memory, and cognition: Essays in honor of Allan Paivio* (pp. 65-89). Hillsdale, NJ: Lawrence Erlbaum Associates.

Mestres-Missé, A., Münte, T. F., & Rodriguez-Fornells, A. (2009). Functional neuroanatomy of contextual acquisition of concrete and abstract words. *Journal of Cognitive Neuroscience, 21*(11), 2154-2171.

Mitchell, R. L., Phillips, L. H. (2007). The psychological, neurochemical and functional neuroanatomical mediators of the effects of positive and negative mood on executive functions. *Neuropsychologia, 45*(4), 617-629.

Mneimne, M., & Powers, A. S. (2012, Sep). Mood induction and affective modulation of startle. 52nd Annual meeting of the Society-for-Psychophysiological-Research, New Orleans, LA.

Morton, J. (1979). Facilitation in word recognition: experiments causing change in the logogen model. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds), *Processing of visible language* (pp. 259-268). Boston, MA: Springer.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review, (76)*2, 165-178.

Nygren, T. E., Isen, A. M., Taylor, P. J., & Dulin, J. (1996). The influence of positive affect on the decision rule in risk situations: focus on outcome (and especially avoidance of loss) rather than probability. *Organizational Behavior and Human Decision Processes, 66*(1), 59-72.

Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt. Rinehart and Winston
(Reprinted 1979. Hillsdale: NJ. Lawrence Erlbaum Associates.)

Paivio, A. (1986). *Mental representations: A dual-coding approach.* New York: Oxford Univerity Press.

Paivio, A. (1991). Dual coding theory - Retrospect and current status. *Canadian Journal of Psychology-Revue Canadienne de Psychologie, 45*(3), 255-287.

Paivio, A. (2013). Dual coding theory, word abstractness, and emotion: a critical review of Kousta et al. (2011). *Journal of Experimental Psychology-General, 142*(1), 282-287

Paivio, A., & Csapo, K. (1973). Picture superiority in free recall: imagery or dual coding? *Cognitive Psychology, 5,* 176-206.

Paivio, A., & Lambert. W. (1981). Dual coding and bilingual memory. *Journal of Verbal Learning and Verbal Behavior, 20,* 532-539.

Paivio A., & te Linde, J. (1982). Imagery, memory, and the brain. *Canadian Journal of Psychology, 36*(2), 243-272.

Palazova, M. Somer, W., & Schacht, A. (2013). Interplay of emotional valence and concreteness in word procesing: an event-related potential study with verbs. *Brain and Langage(125),* 264-271.

Palazova, M., Mantwill, K., Sommer, W., & Schacht, A. (2011). Are effects of emotion in single words non-lexical? Evidence from event-related brain potentials. *Neuropsychologia, 49,* 2766-2775.

Palmer, S. D., MacGregor, L. J., & Havelka, J. (2013). Concreteness effects in single-meaning, multi-meaning and newly acquired words. *Brain Research, 1538*, 135-150.

Pylyshyn, Z. W. (1984). Computation and cognition: Toward a foundation for cognitive science. Cambridge. Massachusetts: The MIT Press.

Pylyshyn, Z. W. (1973). What the mind's eye tells the mind's brain: a critique of mental imagery. *Psychological Bulletin, 80,* 1-24.

Ramon, D., Doron, Y., Fast, M. (2007). Categorization and affect: evidence for intra-hemispheric interactions. *Brain and Cognition, 63*(3), 296-303.

Rinck, M., & Becker, E., S. (2009). Does emotional valence affect performance in non-emotional categorization tasks? *Journal of Behavior Therapy and Experimental Psychiatry, 40,* 385-398.

Rodriguez-Ferreiro, J., Gennari, S. P., Davies, R., & Cuetos, F. (2010). Neural correlates of abstract verb processing. *Journal of Cognitive Neuroscience, 23*(1), 106-118.

Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104*(3), 192-233.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Bream, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382-439.

Sadoski, M., Paivio, A., & Goetz, E. T. (1991). A critique of schema theory in reading and a dual coding alternative. *Reading Research Quarterly, 26*(4), 463-484.

Schacht, A. S., & Sommer, W. (2009). Emotion in word and face processing: early and late cortical responses. *Brain and Cognition*(69), 538-550. Schwanenflugel, P. J., &

Noyes, C. R. (1996). The context availability and the development of word reading skill. *Journal of Literacy Research, 28*(1), 35-54.

Schwanenflugel, P. J., & Stowe, R. W. (1989). Context availability and the processing of abstract and concrete words in sentences. *Reading Research Quarterly,* 24, 114–126.

Shibahara, N., Lucero-Wagoner, B. (2002). Hemispheric asymmetry in accessing word meanings: concrete and abstract nouns. *Perceptual and Motor Skills, 94,* 1292-1300.

Spassova, G., & Isen, A. M. (2013). Positive affect moderates the impact of assortment size on choice satisfaction. *Journal of Retailing, 89*(4), 397-408.

Thomas, N. J. (1999). Are Theories of imagery theories of imagination? An active perception approach to conscious mental content. *Cognitive Science, 23*(2), 207-245.

Toglia, M. P., & Battig, F. (1978). *Handbook of semantic words norms.* Hillsdale, NJ: Erlbaum.

Tryon, R. C., & Bailey, D. E. (1970). *Cluster Analysis.* McGraw-Hill, NY: Maidenhed. Retrieved from http://trove.nla.gov.au/work/10836771

van Hell, J.H., & Candia-Mahn, A.C. (1997). Keyword memories versus rote rehearsal: learning concrete and abstract foreign words by experienced and inexperienced learners. *Lang. Learn*. 47, 507–546.

Vigliocco, G., Kousta, S., Vinson, D., Andrews, M., & Del Campo, E. (2013). The representation of abstract words: what matters? reply to Paivio's (2013) comment on Kousta et al. (2011). *Journal of Experimental Psychology-General, 142*(1), 288-291.

Wang, J., Conder, J. A., Blitzer, D. N., & Shinkareva, S. V. (2010). Neural representation of abstract and concrete concepts: a meta-analysis of neuroimaging studies. *Human Brain Mapping, 31*, 1459-1468.

Watson, D., Clark L. E., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

Zhu, N., Cai, Y., Sun, F., & Yang-yang, Y. (2015). Mapping the emotional landscape: The role of specific emotions in conceptual categorization. Acta Psychologica, 159, 41-51.