The role of emotional valence in learning novel abstract concepts

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7411

Abstract

A recent study by Ponari et al. (2017), showed that emotional valence (i.e., whether a word evokes positive, negative or no affect) predicts age-of-acquisition ratings, and that up to the age of 8-9, children know abstract emotional words better than neutral ones. On the basis of these findings, emotional valence has been argued to provide a bootstrapping mechanism for the acquisition of abstract concepts. However, no previous work has directly assessed whether words' valence, or valence of the context in which words are used, facilitates learning of unknown abstract words. Here, we investigate whether valence supports acquisition of novel abstract concepts. Seven to 10 years old children were taught novel abstract words and concepts (words typically learnt at an older age and that children did not know); words were either valenced (positive or negative) or neutral. We also manipulated the context in which words were presented: for one group of children, the teaching strategy emphasised emotional information; for the other, it emphasised encyclopaedic, non-emotional information. Abstract words with emotional valence were learnt better than neutral abstract words by children up to the age of 8-9, replicating previous findings; no effect of teaching strategy was found. These results indicate that emotional valence supports abstract concepts acquisition, and further suggest that it is the valence information intrinsic to the word's meaning to have a role, rather than the valence of the context in which the word is learnt.

Keywords: vocabulary acquisition; abstract concepts; children; emotional valence.

The role of emotional valence in learning novel abstract concepts

Despite its apparent simplicity, learning words presents several challenges: for words referring to physical entities, the referent is rarely present in the visual scene in isolation. In such cases, children can use social and communicative cues to learn the meaning of the word, e.g. when the caregiver looks or points at the referent (Baldwin, 1991), or picks it up to isolate it from the visual background (Morse, Benitez, Belpaeme, Cangelosi & Smith, 2015). Referents are also often not present in the physical environment, as they can be spatially or temporally displaced. Crucially, some words do not have a tangible referent at all, as they refer to abstract concepts, which are characterized by a lack of unique physical features, such as form, colour and texture and hence lack a clearly perceivable referent (Crystal, 2004). How can children learn the meaning of these words?

To date, there are no studies which specifically focus on abstract words' *learning,* with the exception of a few which are focused on emotion words (e.g. Shablack, Becker & Lindquist, 2019). However, from the literature on word processing, a number of hypotheses that provide different answers to the question above, are available. First, it has been argued that abstract concepts are primarily, if not solely, based on linguistic information while concrete concepts are grounded in sensori-motor information (e.g. the dual-coding view; Paivio, 1971, 1986). Evidence in support of this view comprises the finding that concrete concepts activate a large network of brain areas including sensori-motor areas, while processing abstract concepts has often been shown to rely almost exclusively on the so-called language-network, including the superior temporal and inferior frontal cortex in the left hemisphere (Sabsevitz, Medler, Seidenberg, & Binder, 2005). At a behavioural level,

lexical decision latencies for abstract concepts are found to be better predicted by the richness of the linguistic context in which the words appear rather than the number of features (including sensorimotor and perceptual features) associated with the concept, which instead predict latencies for concrete concepts (Recchia & Jones, 2012).

If linguistic information is more relevant for the representation of abstract concepts, it follows that language development is an important precursor to the acquisition of abstract words and concepts. In fact, the dominant theories of how abstract words are learned have focused on the necessity of linguistic cues. For example, the 'syntactic bootstrapping' hypothesis (Gleitman, Cassidy, Nappa, Papafragou & Trueswell, 2005), posits that young children learn abstract words when they have achieved sufficient language competence to use syntactic to semantic co-occurrences in language to map interpretations of ongoing events and states of affairs. According to this view, the syntactic structure of a sentence can provide children with cues to the meaning of "hard" words (verbs and adjectives), including abstract verbs such as "think" or "seem" (e.g. Papafragou, Cassidy & Gleitman, 2007). Consistently with this hypothesis, Shablack and colleagues (2019) found that the sentence structure '*feels about*' facilitates, at least marginally, 3-5 year old children's understanding of novel emotion adjectives, in the absence of other contextual information (Shablack, Becker & Lindquist, 2019).

It is worth noting here that while syntactic information may be important to learning new abstract words, as similarity in syntactic structure can indicate similarity in meaning, the process of bootstrapping from co-occurring utterances could be purely based on probabilistic co-occurrence of given words in given contexts, without necessarily a role for syntactic structure per se (Landauer & Dumais, 1997; Griffiths, Steyvers & Tenenbaum, 2007; Andrews & Vigliocco, 2009). Such

probabilistic accounts of word learning posit that adults and children can extract the meaning of new words from their statistical distribution across the language. Either way, this general view maintains that linguistic context is necessary, and possibly sufficient, to support acquisition of abstract words and concepts. Another way linguistic development could be crucial to the acquisition of abstract concepts through social and cultural transmission. According to Gelman (2009), verbal testimony would be fundamental for children to learn concepts that cannot be acquired through sensory input. For example, deaf children of hearing parents, who are largely deprived of conversations on needs, desires, beliefs, and other mental states, exhibit a delayed development of the understanding of mental states concepts (Peterson & Siegal, 1998).

Consistent with the idea that linguistic development is an important precursor to the acquisition of abstract words and concepts, the first words in a child's vocabulary are mostly concrete nouns, while abstract words are learnt later (Kousta, Vigliocco, Vinson, Andrews & Del Campo, 2011; Ponari, Norbury & Vigliocco, 2017; Schwanenflugel, 1991). Analysing the relationship between Age of Acquisition (AoA) ratings (provided by adults) and concreteness, Ponari et al. (2017) showed that less than 10% of the vocabulary of children aged 4 is abstract; this percentage increases steadily to reach more than 40% of the total vocabulary by the age of 12, with a particularly sharp increase between the age of 6 and 9 (Ponari et al., 2017). However, inconsistent with the idea that linguistic development is the only determinant of abstract words and concepts learning, Ponari, Norbury, Rotaru, Lenci and Vigliocco (2018) demonstrated that children with developmental language disorder (DLD) are not disproportionally impaired with abstract concepts compared to concrete concepts in lexical decision and definition tasks.

Other hypotheses concerning the acquisition of abstract concepts emphasise the role of social development, e,g, the development of the ability to make inferences concerning the speaker's intentions (Tomasello, 2000); or the role of embodied and social information in conjunction with linguistic input (Borghi et al., 2017). For example, the Words as Social Tools hypothesis contends that in order to acquire abstract concepts the scaffolding offered by the physical environment has to be complemented by labels and explanations where the activation of linguistic experience would give rise to embodied effects such as subvocalization (Borghi et al., 2017). An alternative or additional mechanism for abstract concept learning that has been proposed in the literature is analogical reasoning. The hypothesis that abstract word representation is grounded on conceptual metaphors has a long history in Cognitive Linguistics (Lakoff & Johnson, 1980). In developmental studies, it has been argued that children can learn abstract and complex concepts such as "mitochondria" in analogy with more concrete examples of situations such as "power supply" (Gentner & Hoyos, 2017).

These alternative/complementary hypotheses focus on linguistic, cognitive and social development. Kousta et al (2011) provide a different hypothesis, suggesting that emotion can provide a bootstrapping mechanism for learning abstract words. The starting point for this hypothesis is the observation that, statistically, abstract words are more strongly associated to emotion compared to concrete ones (i.e., most abstract words are valenced – either positive or negative; whereas concrete words tend to be neutral, Kousta et al., 2011; Vigliocco et al., 2014; Ponari et al., 2017). If most abstract words have emotional associations, then the child can use them to draw inferences about some aspects of the meaning of the word and the corresponding concept. For example, a child could learn that the word "happy" refers

to an internal state (and therefore is an abstract word) by associating the word to their own feeling and the caregiver's facial expression. Similarly, a child could learn the meaning of "danger" by associating it to the feelings induced by the caregiver's scared facial expression. Thus, in general, the child's appreciation of the emotional valence of a word as associated to a specific social context would support the inference that the word refers primarily to an internal, rather than external state (Kousta et al., 2011; also see Barsalou et al., 2018).

It is important to keep in mind here that this hypothesis remains agnostic regarding whether there is a categorical distinction between abstract and concrete concepts. The basic idea is that all concepts (spanning the range of concreteness) are made of different types of information. They differ, however, with respect to how much they are characterised by sensorimotor (external) and affective (internal) dimensions, with more concrete words being grounded primarily on sensorimotor and more abstract words being grounded on more affective information (Barsalou et al., 2018; Kousta et al., 2011; Vigliocco, Meteyard, Andrews & Kousta, 2009; see also Connell, Lynott & Banks, 2018; and Lynott et al., 2019 for an empirically based estimate of distribution of features referring to different modalities for a large number of concepts, both abstract and concrete). Some support for the hypothesis that more concrete words are grounded primarily on sensorimotor information, while more abstract words are grounded in more affective information, comes from the qualitative analysis of definitions provided by typically developing children (aged 6-12) in Ponari et al. (2018): definitions of concrete concepts included more perceptual, spatial or functional features, while those of abstract concepts included more situational and emotional features. Further evidence for the hypothesis that emotion provides grounding to abstract vocabulary development, was provided by Ponari et al. (2017).

First, the authors assessed the relation between AoA ratings, concreteness and valence; they found that emotionally valenced abstract words (both positive and negative) are learnt earlier than neutral abstract words. The finding that the first abstract words acquired are emotionally valenced (both positive and negative) provides support for emotion to act as a bootstrapping mechanism for the acquisition of abstract words. Furthermore, using an auditory lexical decision task, the authors found greater accuracy for positively valenced abstract words relative to neutral. Crucially, such advantage for valenced words was found for children up to 8-9 years old, but not for older (10-12 years) children. On the basis of the converging evidence from database analyses and experimental data, the authors argued for emotional bootstrapping: valence provides a critical cue to the meaning of abstract words (as referring to internal states), particularly until the age of 9 (Ponari et al., 2017). After this age, Ponari and colleagues speculated that learning of abstract words and concepts can be more reliant on other mechanisms. For example, children could use the statistical information in language, along the lines as discussed above. In contrast to younger children, 9 years olds have amassed sufficient linguistic data (e.g., they are by now avid and skilled readers) to fully take advantage of the statistical information about words' meaning from discourse, as well as explicitly learn new vocabulary in educational settings. These language-based mechanisms would allow for the development of more fine-grained representation for concepts (regardless of concreteness) supplementing the more basic embodied mechanisms based on sensorimotor and affective experience (see Andrews et al., 2009).

Ponari et al.'s study, however, tested what words children *know*, and therefore it only provides indirect evidence on the role of valence in abstract word *learning*, which so far has not been addressed empirically (with the exception of words directly

referring to emotions). In the present study, we test whether the Abstract-via-Emotion hypothesis can account for learning abstract concepts, and what mechanism is at play. Children aged 7-10 were taught novel abstract concepts, either emotionally valenced or neutral. They were provided with the words' definitions, example sentences, pictures and stories, over four consecutive days. If emotional valence supports the learning of abstract concepts, at least up to the age of 8-9 as shown in Ponari et al. (2017), we expect children to learn valenced words better than neutral ones. However, from the available data, it is unclear whether the advantage for emotionally valenced abstract words is due to the intrinsic valence of the meaning of the words or the fact that, in general, valenced words are learnt in emotional contexts (i.e., the fact that a word such as "holiday" occurs in contexts in which other positive concepts are expressed). Importantly, children's understanding of novel emotion words has been shown to be affected by the situational context (Shablack et al., 2019). Furthermore, if valence acts as a bootstrapping mechanism for the acquisition of abstract words, an emotional context could not only further boost learning of valenced abstract words, but also facilitate learning of abstract words that are intrinsically neutral. Therefore here, for half of the children, we used an 'Emotional teaching strategy': children were asked to think about how the words made them feel, and they were presented with sentences and stories that included a large number of valenced words. For the other half, we used an 'Encyclopaedic teaching strategy': children were asked to think about other words with similar meaning, and they were presented with emotionally neutral sentences and stories. This manipulation allows us to assess the role of emotion in the global learning context, beyond words' definitions. If the learning context mediates the effect of emotion on abstract word learning, children taught with

the emotional strategy should learn words better than those taught with the encyclopaedic strategy.

We tested learning by asking children to write down the definitions of the words learnt, and to carry out lexical decisions. Providing definitions is a task that taps directly into the words' meaning but it is also a relatively complex task because it requires not only learning the concept but also being able to express it effectively. On the other hand, lexical decision, although does not tap directly into semantic knowledge, is an easier task that allows us to check whether children had learnt the word and therefore could distinguish taught from non-taught words.

Method

Participants

Seventy-six children aged 7-10 years (35 females, average age = 9.53, range = 7.88-10.82) were recruited from mainstream schools in Southeast England. All children were native English speakers and had no history of developmental disorders or reported special educational need. Twenty-four children were at the end of school year 3 (7-8 years old, equivalent to 2nd grade elementary in the US educational system), 27 children at the end of year 4 (8-9 years old), and 25 at the end of year 5 (9-10 years old).

Children were screened for non-verbal cognitive abilities (Matrix Reasoning test of the Wechsler Abbreviated Scales of Intelligence, WASI; Wechsler, 1999) and receptive vocabulary (British Picture Vocabulary Scale, BPVS; Dunn, Dunn, Whetton, & Burley, 1997) and assigned to the 'Emotional' or 'Encyclopaedic' strategy (see 2.3 for details). Seven children did not complete testing, leaving data

from 69 children (35 emotional, 34 encyclopaedic) for analysis[1]. Children assigned to

the two strategies did not differ for average age, vocabulary and non-verbal reasoning

skills (see Table 1).

The study was approved by the University College London Research Ethics

Committee (project title "How do children learn abstract concepts?"; Ref. 0143/001).

Informed, written consent was obtained from the parents, and verbal assent was

obtained from the children before each session.

~ Please insert Table 1 about here ~

Materials

Twenty-four abstract words between 5-and 7-letter long were chosen from a

pool of 3,505 words for which normative data on the following lexical variables could

be obtained: Age of Acquisition (AoA) (Kuperman, Stadthagen-Gonzalez, &

Brysbaert, 2012), concreteness (Brysbaert, Warriner, & Kuperman, 2014), valence

(Warriner, Kuperman, & Brysbaert, 2013), and frequency taken from the CBBC

channel's subtitles (a BBC channel targeted at children between 6 and 12 years of

age; van Heuven, Mandera, Keuleers & Brysbaert, 2014). Selected words had an AoA

> 10.5 years. 12 words were selected with an emotional valence ratings were > 5.5

(i.e. positive, N=6) or < 4.5 (i.e. negative, N=6), the remaining 12 words had valence

ratings between 4.5-5.5 and were considered neutral. Emotional (positive and

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[1] A Power analysis conducted using G*Power v.3.0.10 to determine the sample size needed to detect a moderate effect size in a repeated measures ANOVA with within-between interactions, 6 groups (3 age groups x 2 strategies) and 2 levels of the within-subject variable indicated that a total sample size of 66 would give us a power of 83% to detect a medium-sized effect. For a smaller effect, we would need over 200 children.

negative) and neutral words were matched on the variables mentioned above (see

Table 2). Words were arranged in 17 lists of 12 words, pseudo-randomly selected

from the set of 24 (each word was included in at least 5 of the lists). A list of all

words used is presented in Appendix A.

~ Please insert Table 2 about here ~

Procedure

Teaching occurred in a quiet room in the children's schools (e.g., the school's

library), in one 20-minute session per day for four consecutive days (see Figure 1),

during a regular school day. Children were randomly allocated to groups of 4 based

on their age (e.g. 4 children in Year 3 were taught together); each group was then

randomly assigned to a teaching strategy and to one of the 17 lists. Each of the 24

words was learnt by an average of 36 children (range: 32-44). Children were blind to

the experimental manipulation. Two experimenters were present in the room in each

session: the main experimenter conducting the training was familiar with the

Abstract-via-Emotion hypothesis, but not aware of any potential difference related to

the children's age; a second experimenter was always present to observe the session

and make sure there were no differences in the delivery of the training.

Each daily session on days 1-4 was scripted in order to avoid experimenters'

biases, and structured in a way to maximise children's motivation to engage with the

task, while at the same time giving the researchers the opportunity to reiterate the

words' definitions, and to provide context for the two teaching strategies. Therefore,

after an initial exposure with the words' definitions, each training day involved

activities and games using the words. These were meant to make the sessions

engaging and fun for the children therefore performance was not recorded during these games.

~ Please insert Figure 1 about here ~

Day 1: exposure. On day 1, children were exposed to all 12 words on their list. At the beginning of the session, each child was randomly given 3 laminated cards with a word printed on each. Each child was asked to read aloud the three words on the cards they were given, and were asked to indicate whether they already knew their meaning[2].Then, they were presented with 12 slides, one at a time, containing the words on their list and their definitions (see Appendix A for the definitions provided and Figure 1a for an example slide). After going through all the definitions one by one, the children played a game of word bingo: each child was given a bingo card (A4 laminated sheets) with 9 words printed on it, randomly selected from the 12 in the list. The researcher read aloud one word at a time and first asked all the children if they could remember its meaning, then presented the definition one more time. Children who had the word on their bingo cards were asked to cross it out.

Day 2-3-4: teaching phase. Teaching was focused on 4 different words each day. The four children in each group were given one word-card each and they were asked to read the word aloud. Children were asked if any of them could remember the meaning of any of the 4 words from the exposure on day 1; then they were presented with the definitions again, along with example sentences that included the word, and

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[2] Only on three occasions a child argued they knew one of the words, but upon further questioning it was clear they did not know the correct meaning of any of the words we used.

with related pictures (see Figure 1b for an example of the sentences and pictures used in the Emotional Strategy group).

After going through definitions and example sentences for all 4 words, children were presented with a story in which the four target words were replaced by gaps. The stories were printed on a laminated A3 sheet; the four cards containing the words trained on the day were aligned at the bottom of the laminated sheet. The researcher read the story aloud once through the end, indicating the gaps. Then, the story was read again and when a gap was reached, the children were asked to say aloud which of the four words would fit to complete the gap. Once a word was chosen, the researcher asked the other children if they all agreed with the placement, then the card corresponding to the word was picked up and placed on the story. Once all four gaps were filled, the completed story was read aloud one more time, and the children were asked to explain why the words were placed to fill a particular gap (i.e., to recall their meaning again). Sentences and stories emphasized emotional information for children assigned to the 'Emotional strategy', or linguistic/encyclopaedic information for those assigned to the 'Encyclopaedic strategy'. In order to assess the independent contribution of words valence and teaching strategy, the overall valence of the stories and the valence of the words were orthogonally manipulated (see Appendix B for examples of the sentences, and Appendix C for examples of the stories).

Following the completion of the stories, the four laminated word-cards were again distributed to the children, who were asked to generate a sentence including the word that was given to them and tell it to the group. If a child could not generate a sentence because they could not remember the meaning of the word, the other children were asked to help. If no one could help, the definition was read again, and the child was asked again to produce a sentence. If the child could still not able to

generate a sentence, the other children were again allowed to help. After providing sentences for all 4 words, children were given a mind-map each to fill in. Mind maps were completed one at a time, so that all children could participate, although each child was in charge of one. The experimenter asked each child: 1) to say aloud and write down the meaning of the word; 2) to mention and write down a place or situation in which they might hear/read that word; 3) another word similar in meaning (for the encyclopaedic strategy) or how the word would make them feel (for the emotional strategy). Once the four mind-maps were all completed, all children were given the time to draw a picture related to the word on their card.

Day 5: testing. Learning was tested using pen-and-paper tests. First, children were presented with a list including all 24 words (12 learnt, 12 non-trained words) randomly intermixed with 24 nonwords, and asked to perform lexical decisions ("Is this a real word?"). Then, children were presented with all 24 words, and asked to write a definition next to the words they knew, and leave the ones they did not know blank.

Scoring of definitions

The definitions provided to the words children had been exposed to in the learning phase were scored by two independent researchers blind to the study hypotheses and age of the children, according to the Wechsler Intelligence Scale for Children (WISC) vocabulary sub-test scoring criteria (Wechsler, 2014). The WISC uses a 0-2 scale with the following criteria: 2 points were given to answers showing full semantic understanding of the word, being defined in a precise and unequivocal way (e.g., a garden is a plot of ground at the back of the house where you can grow flowers and play); including one or more features of the concept (e.g., a diamond is

very expensive and it shines); the main use or purpose (e.g., a knife is used to cut); or synonyms (e.g., join means put together). 1 point was given to correct answers that showed poverty of content (e.g., giraffe is an animal; anger is a feeling); including a minor use of purpose (e.g., evening is when we dine); or trivial features of the concept (e.g., the bicycle has a seat). 0 points were given if no answer was given; if the answer was obviously wrong; or included a repetition of the concept, suggesting the child did not understand the meaning of the word despite being familiar with its use (e.g. to take a photo).

A third independent researcher moderated instances in which the two scorers did not agree (2.5%) or only one scorer awarded a score of 0 (1.5%).

Results

Lexical decision

Lexical decision accuracy was analysed using generalised mixed-effect models (glmer) with the package 'lmerTest' (Kuznetsova, Brockhoff & Christensen, 2016) run in R Studio Version 1.2.1335 (RStudio Team, 2018). Average lexical decision accuracy is shown in Figure 2.

~ Please insert Figure 2 about here ~

First, we tested the difference between taught, non-taught words and nonwords by fitting a model that included the school year (3, 4 and 5) × stimulus type (trained, non-trained, non-word) interaction and the main effects. There was a significant main effect of stimulus type, with non-trained words (β = -5.06, SE =

0.76, $p < .001$) and non-words ($\beta = -3.54$, SE $= 0.81$, $p < .001$) being recognised less

accurately than trained words. No effect of school year was found (Year 4 vs Year 3:

$\beta = -0.23$, SE $= 0.97$, $p = .813$; Year 5 vs Year 3: $\beta = 14.66$, SE $= 10.74$, $p = .989$),

nor any interaction involving school year (all p > .252).

Accuracy for trained words was at ceiling for all groups (> 99%), therefore we

could not assess any effect of valence or teaching strategy on lexical decision

accuracy.

Definitions

Average definition scores (computed as percentage of total achievable score

within each valence category), are shown in Figure 3. First, we conducted a mixed

ANOVA on the definition scores with valence (neutral, valenced) as within-subject

variable, and school year (3, 4 and 5) and teaching strategy (encyclopaedic,

emotional) as between-subject variables. This analysis revealed a main effect of

valence, $F(1, 63) = 12.457$, $p = .001$, $\eta_p^2 = .165$, with valenced words (M $= 41.8$, SE $=$

3.4) defined better than neutral words (M $= 32.4$, SE $= 2.9$) and a main effect of

school year, $F(2, 63) = 5.255$, $p = .008$, $\eta_p^2 = .143$, with performance significantly

increasing from Year 3 (M $= 24.5$, SE $= 5.1$) to year 4 (M $= 38.8$, SE $= 4.8$), but no

significant difference between Year 4 and Year 5 (M $= 47.9$, SE $= 5.2$). Crucially, the

valence × school year interaction was also significant, $F(2, 63) = 4.545$, $p = .014$, $\eta_p^2 =$

.126. There was no significant effect of teaching strategy, nor any significant

interaction including this variable (all ps > .05). We explored the valence × school

year interaction by looking at the effect of valence separately in each school year.

Valence significantly affected performance of Year 3 ($M_{val} = 33.39$, $SE_{val} = 21.78$;

$M_{neu} = 15.67$, $SE_{neu} = 16.63$; $t(21) = -4.202$, $p < .001$) and Year 4 children ($M_{val} =$

44.67, SE_{val} = 26.65; M_{neu} = 32.52, SE_{neu} = 25.48; $t(24)$ = -2.415, p = .024), but not

Year 5 children (M_{val} = 47.39, SE_{val} = 33.24; M_{neu} = 48.62, SE_{neu} = 29.67; $t(21)$ =

.295, p = .771).

~ Please insert Figure 3 about here ~

As children did not all learn the same words, and differences between lists

might arise due to additional variables that can affect word's learning, including

differences in the sensorimotor properties that can be associated with the words (e.g.

rogue can be more easily associated with an individual and therefore to some degree

of sensorimotor experience, compared to *insight*), we also analysed the data using

mixed models. Due to the ordinal nature of the definition scores, we used cumulative

link mixed models fitted with the Laplace approximation (CLMM; package 'ordinal';

Christensen, 2015), run in RStudio Version 1.2.1335 (RStudio Team, 2018). As

recommended by Barr et al., (2013), we included random intercepts for subjects and

items and the random slopes for our effects of interest: valence (by subject) and

teaching strategy (by item). We started from a model including the main effects of

school year, valence and teaching strategy and the three-way interaction between

them, as well as the following continuous predictors: words' AoA (Kuperman et al.,

2012), length, CBBC frequency (van Heuven et al., 2014), and sensorimotor strength

(a composite measure obtained from ratings for 11 sensorimotor dimensions

associated to a word, Lynott et al., 2019)[3]. All continuous predictors were centered on

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[3] We did not add vocabulary and non-verbal reasoning scores to the models because they are highly correlated with age (and therefore school year). When added to models testing the effect of valence and strategy separately by school year, vocabulary and non-verbal reasoning are significant predictors of performance only for children in year 4, but the overall results are not affected.

the mean. We performed model comparisons using likelihood ratio tests to evaluate

the contribution of each factor or interaction. Data and code are available at

https://osf.io/wsk2u/ (Ponari, Norbury & Vigliocco, 2020). The results of these

analyses are reported in Table 3; they confirm and extend the results of the ANOVA

presented above.

AoA, length and sensorimotor strength were significant predictors of

children's performance (i.e. when removed from the full model, the model fit

decreased). Dropping the school year × valence interaction significantly decreased the

fit of the model, however the model fit was not affected by dropping either the school

year × teaching strategy or the teaching strategy × valence interaction. Separate

models were fit per each school year to further investigate the school year × valence

interaction. Removing the effect of valence significantly decreased the model fit in

Year 3 and Year 4, but not in Year 5.

~ Please insert Table 3 about here ~

Discussion and conclusions

The purpose of the present study was to test the hypothesis that emotional

valence may provide a bootstrapping mechanism for the acquisition of abstract

concepts. Ponari et al. (2017) showed (from analysis of adults' age-of-acquisition

ratings) that emotionally valenced abstract words are acquired earlier than neutral and

that, around the age of 8-9 years old, children are more accurate in processing abstract

positive, relative to neutral abstract words. These results are in line with the

hypothesis that emotion provides a bootstrapping mechanism for abstract word

learning (Kousta et al., 2011; Ponari et al., 2017), however they are based on adults' ratings of age-of-acquisition and children's *knowledge* of abstract words, thus providing only indirect evidence about how children *learn* these words.

Here, we assessed for the first time the role of valence in learning novel abstract words. Emotional information can be intrinsic to the word meaning (as is the case for emotionally valenced words) and can be also provided in the learning context. Our study disentangled these two contributions by manipulating both word valence and context in which the word is learnt (in terms of number of valenced words provided as linguistic context for the word): one group of children were taught valenced (positive and negative) and neutral abstract words using a teaching strategy emphasizing emotional information, while the other group were taught valenced and neutral abstract words in a more neutral context, where the teaching emphasized encyclopaedic information.

The lexical decision task demonstrated that exposure to words in both our teaching strategies was very effective: children in all groups were able to recognize the trained set of words more accurately than non-trained controls, and non-words. In fact, repeated exposure over the 4 sessions was enough to learn the 12 word-forms at ceiling.

In the definitions task - that more directly taps into children's appreciation of the meaning of the words - we found that children could define valenced abstract words better than neutral ones, but crucially this was significant only for children in school year 3 and 4 (corresponding to the age range 7-9 years). The effect of valence was not significant in school year 5 (age 9-10 years). We did not find any effect of teaching context.

The learning advantage of valenced words

The results concerning the effect of word valence converge with the developmental change observed by Ponari et al. (2017). They suggested that this is likely because by the age of 10, children's linguistic abilities are developed enough to mediate further development of abstract vocabulary. For example, as reading proficiency develops, children are also more likely to acquire new vocabulary from written texts and recover abstract meaning from the surrounding linguistic context, in line with the statistical mechanisms proposed by Distributional Semantics models (e.g (Lenci, 2018). Interestingly, a recent study showed that knowledge of emotion words (representing a subset of abstract valenced words) increases across childhood to plateau at around age 10-11, but the quality of the definitions provided continued to improve until age 18, with young children using more concrete strategies (e.g. referring to physiological markers of the emotions, or concrete situations), and a tendency to use more abstract strategies (e.g. referring to general definitions, causes and characteristics of emotions) that increases with age (Nook et al, 2019). It could be argued that the developmental changes observed by these authors can be accounted for by similar mechanisms as the one proposed by Ponari et al. (2017) and supported by our results: for young children, emotion words are tied to the concrete social context in which they are learnt. For older children, however, the much larger implicit and explicit linguistic experience make it so that concrete affect is not the only aspect of the meaning of these words/concepts.

Research on how children label others' emotions also shows early effects of valence, with young children (around the age of 3.5) only categorizing facial expressions into two groups ("positive" and "negative") and learning to provide more specific emotion labels over the following years (Widen, 2013). Younger children

also tend to report feeling either positive or negative emotions at any given time and only report experiencing more than one emotion simultaneously from age 8 (Larsen, To, & Fireman, 2007). An investigation of how children represent emotion concepts themselves showed a similar trajectory: children represent emotions primarily in terms of valence, with the multidimensionality of emotion concept representations increases across age (i.e., reflecting the addition of the arousal dimension; Nook, Sasse, Lambert, McLaughlin, & Somerville, 2017). Thus, the finding of a valence effect in our study may simply reflect this strong early focus on valence (positive and negative) across linguistic and non-linguistic domains. Later on, while valence may continue to be an important organizational principle of emotion-related concepts (which are all abstract concepts), other factors (such as linguistic development) would become important leading to more specific conceptual categories for emotions (organized around linguistic labels), as argued by constructivist views of emotion (e.g., Lindqvist, Satpute & Gendron, 2015) and evidenced in studies of emotion concept representation (Nook, Sasse, Lambert, McLaghlin, & Somerville, 2018) and vocabulary development (present results and Ponari et al., 2017).

In agreement with hybrid views of semantics, we see semantic representations as constituted by different types of features, both embodied as well as linguistics (Andrews et al., 2014; Borghi et al., 2017; Barsalou et al., 2018). Different types of concrete and abstract concepts then would differ in the relative weight of any specific type of feature. Our findings that affective features are important for abstract concepts does not imply that there should not be differences in their weighting depending upon the specific meanings (e.g., events vs properties). Although we included in the items both words referring to events (nouns) and properties (adjectives), their distribution was not balanced, precluding us from carrying out analyses to assess such differences.

Our items also included abstract words that varied in the extent to which they evoke sensorimotor associations (Lynott et al., 2019) and sensorimotor strength was found to be a significant predictor of children's performance, as well as emotional valence. Future studies should further investigate the role of emotional valence in learning and processing abstract words that vary in both grammatical class and levels of sensorimotor associations.

The role of teaching strategy

While the effect of words' valence was significant, the effect of teaching strategy (emotional vs. encyclopaedic) was not significant in any of the groups. These results suggest that it is emotional information pertaining to the word's meaning that supports abstract words learning, while emotional information in the more global learning context does not further boost learning of valenced abstract words, and it does not provide support to neutral words.

The lack of an effect of learning context might have come about because we only manipulated emotion in the linguistic content that children experienced during the experiment (i.e., presenting children with sentences/stories which included a larger number of words with emotional associations beside the trained words), but we did not manipulate non-verbal cues (e.g., facial expressions, prosody). However, the results suggest that children were able to grasp the intrinsic emotional valence of the words from their definitions, which were also provided linguistically and without manipulation of non-verbal cues. A way to account for the lack of an effect of our teaching strategy is in terms of how strongly the emotional information provided is associated to the word/concept. Valence, as expressed in the definitions, is part of the meaning of the words, while the global learning context is less informative with

regards to the specific meaning of each word as valenced words can be used in neutral contexts and neutral words can be found in valenced contexts. It remains, however, for future research to explore the role of emotional as well as social context (verbal and non-verbal) in situations in which children learn new abstract concepts in an implicit manner, without being provided with definitions of the words.

Conclusions

To conclude, our results provide novel evidence for the role of emotion in learning abstract context in children up to 8-9 years of age and therefore are in general support for the hypothesis that affect provides a bootstrapping mechanism for the acquisition of abstract concepts. The results, however, are also compatible with a role for language in learning abstract concepts later on, once children have developed sufficient experience to extract abstract meanings (as abstract words are less frequent in the language) from linguistic contexts.

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Table 1. Participants' age, gender and performance on standard tests of non-verbal reasoning and vocabulary.

Strategy/ School year	N	Male/ Female	Mean Age	Matrix Reasoning	BPVS
Emotional	**35**	**21/14**	**9.35 (0.86)**	**19.34 (5.98)**	**117.69 (14.44)**
3	11	7/4	8.32 (0.28)	15.18 (5.19)	109.82 (13.46)
4	12	7/5	9.33 (0.28)	22.58 (2.73)	117 (8.87)
5	12	7/5	10.32 (0.30)	19.92 (6.76)	125.59 (15.64)
Encyclopaedic	**34**	**18/16**	**9.34 (0.84)**	**18.55 (6.63)**	**122.26 (12.52)**
3	11	6/5	8.39 (0.35)	18 (7.01)	116.36 (12.35)
4	13	7/6	9.38 (0.29)	16 (5.75)	122.85 (13.22)
5	10	5/5	10.35 (0.35)	22.5 (5.35)	128 (8.18)

Note: Standard deviations appear in parentheses below means.

Table 2. Lexical and sublexical characteristics of stimuli.

Variable	Valence category		t(22)	p
	Emotional	Neutral		
Concreteness[a]	2.00 (0.2)	2.14 (0.3)	1.211	0.239
Length (n. of letters)	6.00 (0.9)	6.00 (0.9)	0.000	1
Valence	4.89 (1.6)	4.97 (1.7)	0.754	0.466
└ distance from neutrality	1.27 (0.35)	0.25 (0.14)	-9.190	< .001
Age of Acquisition[c]	11.75 (1.0)	12.05 (1.5)	0.586	0.564
CBBC frequency[d]	3.15 (0.6)	2.90 (0.6)	-1.037	0.311

Note. Standard deviations appear in parentheses below means. a. Brysbaert et al., 2014; b. Warriner et al., 2013; c. Kuperman et al., 2012; d. Van Heuven et al., 2014.

Table 3. Results of the cumulative link mixed model analyses of the definition scores.

Models	Effect tested	Model comparison statistics		
		AIC_diff	LogLik_diff	p
Reference model: Year:Strategy:Valence + aoa + len + sens + freq				
Reduced models: Year:Strategy:Valence + len + sens + freq	aoa	-3.83	2.92	.016*
Year:Strategy:Valence + aoa + sens + freq	len	-6.38	4.19	.004*
Year:Strategy:Valence + aoa + len + freq	sens	-2.95	2.47	.026*
Year:Strategy:Valence + aoa + len + sens	freq	-0.69	1.34	.101
Year:Strategy + Year:Valence + Strategy:Valence + aoa + len + sens + freq	3-way inter.	3.02	0.49	.613
Reference model: Year:Strategy + Year:Valence + Strategy:Valence + aoa + len + sens + freq				
Reduced models: Year:Valence + Strategy:Valence + aoa + len + sens + freq	Year x Strategy	3.83	0.09	.917
Year:Strategy + Strategy:Valence + aoa + len + sens + freq	Year x Valence	-3.75	3.87	.021*
Year:Strategy + Year:Valence + aoa + len + sens + freq	Strategy x Valence	1.75	0.12	.620
Year 3				
Reference model: Strategy + Valence + aoa + len + sens + freq				
Reduced models: Valence + aoa + len + sens + freq	Strategy	1.95	0.02	.825
Strategy + aoa + len + sens + freq	Valence	-5.18	3.59	.007*
Year 4				
Reference model: Strategy + Valence + aoa + len + sens + freq				
Reduced models: Valence + aoa + len + sens + freq	Strategy	1.93	0.03	.792
Strategy + aoa + len + sens + freq	Valence	-3.71	2.86	.017*
Year 5				

Reference model: Strategy + Valence + aoa + len + sens + freq				
Reduced models:				
Valence + aoa + len + sens + freq	Strategy	1.89	0.53	.744
Strategy + aoa + len + sens + freq	Valence	1.98	0.01	.893

aoa = Age of Acquisition; len = length; sens = sensorimotor strength; freq = frequency; AIC_diff = reference model AIC–reduced model AIC (negative values indicate the reference model is better fit); LogLik_diff = reference model Log Likelihood–reduced model Log Likelihood (positive values indicate the reference model is better fit); asterisks indicate significant p values.

DAY 1
- Background screening
- Exposure (12 words)
  1. Definitions (a)
  2. Bingo

DAYS 2-3-4
- **Teaching phase (4 words each day)**
  1. Definitions (a) +
     Sentences/pictures (b)
  2. Stories (fill the gap)
  3. Generate sentences
  4. Mind map (c)

DAY 5
- **Assessment**
  1. Lexical Decision
  2. Definitions

a)

CRUDE
Not having the skill or knowledge of how to behave appropriately and how to be well-mannered

b)

I was so upset when I saw how crude Bill's manners were! Very disgusting indeed!

c)

WHERE MIGHT YOU HEAR IT?   WHAT IS IT?

DRAW A PICTURE ABOUT IT!
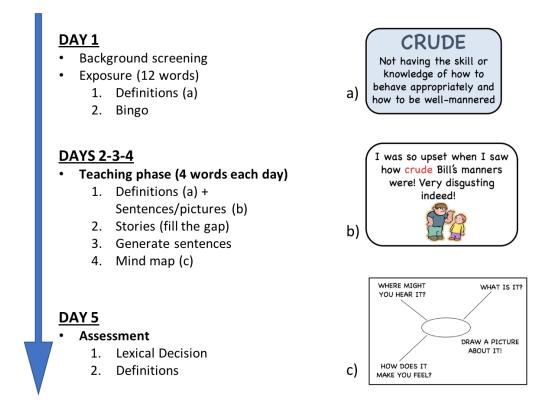
HOW DOES IT MAKE YOU FEEL?

Figure 1. Summary of the procedure with examples of (a) definitions; (b) sentences; and (c) mind maps. (b) and (c) in this example refer to the Emotional strategy.
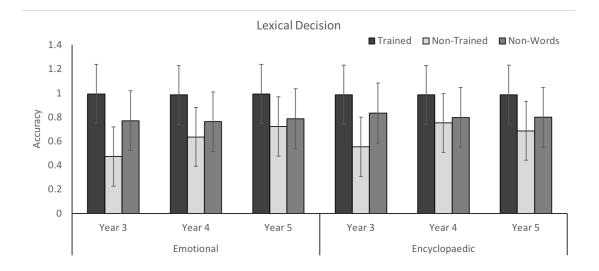
Figure 2. Accuracy (proportion correct) at the lexical decision task for children in Year 3, Year 4 and Year 5 at the lexical decision task as a function of word-type and teaching strategy. Means and confidence intervals have been computed from a model including the three-way interaction between school year, word-type and teaching strategy (only fitted for illustrative purposes). Error bars represent 95% confidence intervals based on fixed effects uncertainty and random effects variance.
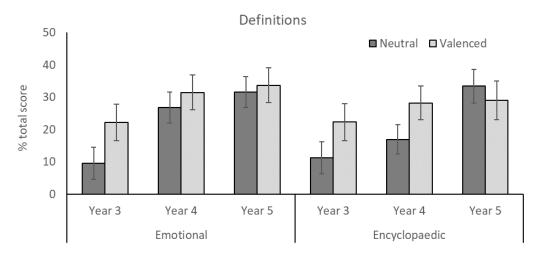
Figure 3. Average total definition score of children in Year 3, Year 4 and Year 5 as a function of valence and teaching strategy. Error bars represent standard deviations.

Appendix A

	WORD	VALENCE*	DEFINITION
EMOTIONAL	tyranny	3.19	Situation in which a single person rules the family/company/country in a cruel and brutal way
	crude	3.24	Not having the skill or knowledge of how to behave appropriately and how to be well-mannered
	adverse	3.68	Something that is unpleasant or harmful
	covert	3.79	Something secret and hidden away
	rogue	3.89	A person who is dishonest or mean
	liable	4.00	To be held responsible for something (especially legal)
	tactic	5.70	A strategy used to achieve a goal, for example in playing chess or football
	morale	5.95	When a person or a group feels enthusiastic and confident
	genre	6.00	A specific type of writing, film, or music
	karma	6.28	The idea that what will happen to you in the future depends on what you have done in the past
	ambient	6.33	Surrounding environment like lighting and décor of a room
	insight	6.76	The ability to get a deep understanding of something or someone
NEUTRAL	output	4.85	The amount of something produced by a person, machine, company…
	status	4.89	A person's social position or rank in comparison with that of other people in the group.
	proxy	4.95	A person who is allowed to act for another person: a substitute.
	reform	5.05	To change something like a law in order to make it better
	dynasty	5.16	Series of people from the same family who play an important role in business or politics
	analogy	5.24	To find similarities between two different things
	trend	5.33	A general direction in which something is developing or changing
	lucid	5.35	Something that is very clear and easy to understand
	ethnic	5.36	Describing a group of people who have the same race, country and culture
	paradox	5.4	A person or thing that seems to combine opposite features or qualities
	basis	5.42	Something (like an idea) from which another thing develops or can develop
	premise	5.43	A statement that describes the starting point of an argument or negotiation

* Valence ratings from Warriner et al. 2013

Appendix B

Examples of sentences used for the words TREND and REFORM in the Emotional

and the Encyclopaedic strategies.

Word	Emotional	Encyclopaedic
Trend	The *trend* toward playing games on the iPad or Nintendo is fantastic! I love my iPad, but nobody likes PCs anymore, they are not trendy.	It is clear that today the *trend* is toward playing games on the iPad or Nintendo. The PC is not trendy anymore.
Reform	I am extremely cross about the government's planned *reform* of the health service, which is hugely unpopular. The change will make health care worse and many people will suffer.	I read an article about the government's planned *reform* of the health service, which will take place next year. They are often changing things and many people will change jobs.

Appendix C

Six emotional and six encyclopaedic stories were created, each containing the
4 target words taught on each day. Valence of the stories and valence of the words
were orthogonally manipulated, so that valenced words (as well as neutral) could be
embedded in neutral stories, and neutral words (as well as valenced) could be
embedded in valenced stories. This manipulation allowed us tease apart the
independent contribution of word's valence and teaching strategy.

**Examples of stories used for the emotional and the encyclopaedic
strategies for the words GENRE, INSIGHT, LUCID and TREND can be found
below.**

50 adults rated the emotional versions and 50 adults rated the neutral versions
independently on how easy to understand the stories were, on a 1 to 7 scale where 1 =

Words	Emotional	Encyclopaedic
Genre, Insight, Lucid, Trend	Tom loves to read many fiction _[GENRE]_ so that he has _[INSIGHT_ into many exciting characters and their thrilling lives. He loves reading more when the author's writing is _[LUCID]_ and easy to follow and makes him feel happy. There is a _[TREND]_ for students to read fewer books now because of television and computers, which is really sad. But Tom finds reading very pleasant and makes sure he reads every night before he goes to sleep.	Tom reads a large variety of fiction [GENRE] so that he has _[INSIGHT]_ into many kinds of characters and their complex lives. He reads more when the author's writing is _[LUCID]_ and flowing. There is a _[TREND]_ for students to read fewer books now because of television and computers, which is typical. But Tom finds reading very easy and makes sure he reads every night before he goes to sleep.

'very difficult' and 7 = 'very easy'. The two different versions of each story were
rated as equally easy to understand (emotional stories M = 6.02, SD = 0.75; neutral
stories M = 6.11, SD = 0.82; t(49) = 0.569 , p = .572).

The emotional and neutral versions of each story differed in terms of valence:
considering all the content words in the stories, average hedonic valence (distance

from neutrality) of the words included in the stories used in the Emotional strategy

(mean = 1.45) was significantly higher than the hedonic valence of words used in the

Neutral stories (mean 1.20, t = 3.301, p = .001). 67% of the content words of the

emotional stories were valenced, with 34% having a hedonic valence score ≥ 2

(average hedonic valence of these words: 2.52). Of the content words of the Neutral

stories, 58% were valenced, and only 19% of had a hedonic valence ≥ 2 (average

hedonic valence = 2.36).