

Valence, Arousal and Concreteness Mediate Word Association

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This study was partially supported by grants RED2018-102615-T and PGC2018-097145-B-I00 from the Spanish Government, and H2019/HUM-5705 from the Comunidad de Madrid.

The data and materials for the analysis were collected from the publicly available sources cited in the article, and the resulting files and datasets are available upon request. The analysis was not preregistered.

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Abstract

Background: Given the impact of lexical properties such as valence, arousal and concreteness in language processing, recent computational methods have been designed to extrapolate these values from different sources, such as word co-occurrence or word association corpora. These methods have been proven to be particularly successful approaches to extract lexical features from word association data. Consequently, valence, arousal and concreteness seem to be indeed represented in word association, and we hypothesize that they might in fact be critical mediators in the process.

Method: To prove our hypothesis, we paired the cue and associate words from three databases in three different languages with their valence, arousal and concreteness values. We then conducted linear regression analyses to see if an associate's score in each dimension could be predicted by the scores of its cue word.

Results: The analyses showed that the score of the cue words in each of the three dimensions is a strong predictor of the scores of their associates in the same dimension. Furthermore, words that were more strongly associated tended to have more similar scores.

Conclusions: We showed that across different languages, word association is mediated and can be predicted by concreteness, arousal and valence.

Keywords: word association; valence; arousal; concreteness

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Emotion is a critical component of language, which can be loaded both in the tone of the speaker as well as in the very words that they use. While the former is generally limited to spoken language only, the latter is present in every form of verbal communication, including the oral and written formats and, as such, has been of much interest to psycholinguistic research. Stemming from the dimensional approaches postulated by research on human affect and emotion (Russell, 1980; Russell et al., 1989), psycholinguists have traditionally divided the emotionality of words into two major dimensions: valence and arousal (Citron et al., 2013). Some authors also include dominance as a third dimension, defined as the degree to which the word represents something dominant or strong, compared to submissive or weak (e.g., subordinate vs. boss) (Warriner et al., 2013).

Valence represents the hedonic value of the word (i.e., whether it represents a pleasant or unpleasant concept; e.g., *love vs hate*), and its influence in word processing has been extensively studied. Neurocognitive studies have shown that positively and negatively valenced words, relative to neutral words, rapidly attract an individual's attention during emotional information processing (Citron et al., 2013; Kissler et al., 2009; Palazova et al., 2011). Neuroimaging studies have also shown that positive and negative words activate brain areas that are associated with emotional conflict and processing of emotion and reward (Lewis et al., 2007). As recently reviewed by Citron (2012) and Hinojosa et al. (2020), valence is a critical emotion-related dimension of words that modulates their acquisition, learning and processing (recognition and production).

On a behavioral level, studies on single word processing—usually lexical decision and naming tasks—have provided somewhat conflicting pieces of evidence. Some studies have found that both positive and negative words elicit shorter reaction times (RT) compared to

neutral words in these tasks (Vinson et al., 2014; Yap & Seow, 2014), while others indicate that negative words elicit the longest RT, followed by neutral and then by positive words (Estes & Adelman, 2008; Rodríguez-Ferreiro & Davies, 2019). Recent studies, however, have shown that the effect of valence on RT is heavily modulated by word frequency (Kuperman et al., 2014; Scott et al., 2014). According to this account, RT would distribute in a progressively smaller manner from negative to neutral, and from neutral to positive stimuli at lower word frequencies, but as frequency increases, these valence effects would get less pronounced.

The valence of a stimulus can even affect processing after the stimulus itself has already faded. Several studies have found that the response to an emotionally valenced word in a lexical decision task is facilitated when it is preceded by a stimulus of the same valence. This is known as *affective priming*, and it has been documented when the priming stimuli are words, pictures (Spruyt et al., 2002), musical notes (Sollberge et al., 2003; Steinbeis & Koelsch, 2011) and even flavors and smells (Hermans, 1998; Veldhuizen et al., 2010). However, studies on the effects of each specific valence have found that, at least when the priming stimuli are written words, this effect only takes place when the congruent pairs are positive words, being negligible for congruent negative pairs (Rossell & Nobre, 2004; Rossell et al., 2000; Sass et al., 2012). Interestingly, valence also influences processing beyond single word paradigms, as information and facts have been shown to be better processed and learned when woven in a text with a large number of positive words than in a text with predominantly neutral words (see Frances et al., 2020, for a summary).

The second critical dimension of word emotionality is arousal, which refers to the galvanizing properties of the word (i.e., whether the word is calming or activating). While arousal and valence can sometimes overlap — in fact, positive and negative words tend to be more arousing than neutral words (Larsen et al., 2008)—, they represent clearly separate notions. For instance, the words *serene* and *excited* both represent positive concepts, but the

latter is much more arousing than the former; likewise, the words *melancholy* and *wrath* both represent negative concepts, but the latter is much more arousing than the former.

Research on arousal, while much less extensive than that on valence, has yielded somewhat parallel results. Highly arousing words have been shown to activate specific brain areas linked to the detection of threats and the eliciting of the flight-or-fight response (Colibazzi et al., 2010, Lewis et al., 2007). Much like with valence too, some of the research on lexical decision and naming tasks has found slower RT for low-arousal words (Recio et al., 2014) while other studies suggest that arousal has no effect on response latencies (Rodríguez-Ferreiro & Davies, 2019; Yao et al., 2016). As in the case of valence, Kuperman et al. (2014), indicated that arousal effects are also contingent on word frequency, as highly arousing words elicit slower RT than low arousal words at low frequency, with the effect becoming progressively smaller as frequency increases. Finally, in regard to priming, the congruency between the arousal of the priming stimulus and the following word has also been shown to facilitate lexical decisions (Altarriba & Canary, 2004; Zhang et al., 2012). Furthermore, an interaction effect between arousal and valence has been found too, with larger affective priming effects when either the prime (Zhang et al., 2012) or the target (Hinojosa et al., 2009) are highly arousing.

One of the reasons verbal language is so well suited for transmitting emotions is because of its ability to convey abstract concepts (i.e., concepts that have no material basis, such as *math*, *time* or any word representing a feeling or emotion). This is why concreteness—the degree to which a word represents a concept that has a material basis in the world—has been of particular interest in psycholinguistic research. Originally, research on this dimension pointed to faster processing times for concrete words compared to abstract words, an effect which was known as the *concreteness effect* (Binder et al., 2005, James, 1975, Whaley, 1978). However, recent studies have found that, after controlling for a number of different confounding variables, abstract words actually elicit shorter RT in lexical decision and naming

tasks than concrete words, a finding known as the *abstractness effect* (Barber et al., 2013; Kousta et al., 2011; Vigliocco et al., 2014). Interestingly, Kousta et al. (2011) and Vigliocco et al. (2014) argued that this was caused by the fact that abstract words tend to be more emotionally charged than concrete words and, in fact, demonstrated that the abstractness effect disappeared when all words were neutrally valenced.

However, Crutch and Warrington (2005) offered an alternative explanation, based on the different ways that concrete and abstract words are organized in the brain. In a case study of a patient with semantic refractory access disorder, they reported that the patient had a significantly worse performance when detecting abstract target words embedded in an array of word associates (i.e., words that come to mind when hearing another word; e.g., *holy* and *water* or *spirit*) compared to an array of semantically related words (i.e., words with a similar meaning; e.g., *holy* and *sacred* or *divine*). These results, however, were reversed when the words used were of a concrete nature: concrete target words in semantically related arrays were harder to detect than those in associate arrays. Similar results have been found with healthy patients in a similar task (Crutch & Jackson, 2011) and with the visual word paradigm task (Duñabeitia et al., 2009). These findings suggest that concrete words are organized in a semantically related complex, while abstract words are arranged in associative networks. Similar views have been recently provided by neuroimaging evidence, concluding that, contrary to concrete words, abstract words may not rely on semantic information in their processing, eliciting different neural responses (Barber et al., 2013). Complementary to this study is one by Santos et al. (2011), which found that participants usually generate word associates through simple linguistic processes, such as completion (the cue *holy* elicited the associate *water* because *holy water* is a relatively common concept) and sound similarity (the cue *lumpy* elicited the associate *bumpy* because of their similar phonetic structure). Since abstract words appear to be organized in word association networks, and word association

seems to be based on simple linguistic processes, Barber et al. (2013) suggested that the abstractness effect could be caused by abstract words being processed in faster, more superficial linguistic terms, while concrete words are processed in slower, deeper semantic terms.

Finally, concreteness has also been shown to interact with valence during affective priming. In particular, Yao and Wang (2013, 2014) found that the response facilitation when both the prime and the target are positive words is only present when both words are abstract, and such effect disappears when both words are concrete. Incidentally, they also found that the controversial interaction between valence and arousal was mediated by concreteness: while no interaction between valence and arousal was found for concrete words, a significant interaction between the two was found for abstract words, with positive high-arousal items yielding longer RT than positive low-arousal items, and negative low-arousal items yielding longer RT than negative high-arousal items.

In order to carry out studies on how all these different variables influence language processing, it is paramount to be able to quantify these dimensions. Until very recently, the method utilized to obtain these ratings has been very straightforward: a large number of participants is gathered and then asked to provide subjective ratings for a set of words along these dimensions. Through this procedure, researchers have been able to create databases containing the ratings for a huge number of words. A well-known seminal database of this kind was the Affective Norms for English Words (ANEW), created by Bradley and Lang (1999), which contains the emotional scores for a total of 1,034 words. Since then, however, larger databases of emotional values have been gathered for the English language (13,915 words: Warriner et al., 2013), as well as for other languages such as Dutch (4,300 words: Moors et al., 2013) and Spanish (14,032 words: Stadthagen-Gonzalez et al., 2017). Similar databases have

been created to gather concreteness scores in English (40,000 words: Brysbaert et al., 2014), Dutch (30,000 words: Brysbaert et al., 2014) and Spanish (6,400 words: Duchon et al., 2013).

However, even such a large quantity of items pales in comparison with the sheer number of words that form these languages, meaning that a huge portion of their lexica is yet to be cataloged. Because the process of having participants manually rate these words is excessively slow and expensive for such a hefty task, researchers have devised new methods to computationally quantify the norming of these words without the need for human subjective ratings. The most commonly used procedure relies on calculating the similarity measures of a large number of words from their relative position in text corpora. Ratings for unclassified words can then be extrapolated from their similarity to other words whose emotional ratings are already known. These similarity measures can be acquired through various means, but the one that has shown the greatest success at extrapolating emotional values is that by Van Rensbergen et al. (2016), who obtained these measures through word association data. In a typical word association task, participants are given a specific word—known as cue—and they must respond with the first words that come to mind—known as associates—(see Nelson et al., 2004; De Deyne et al., 2019; Fernández et al., 2018; De Deyne et al., 2013). This method was chosen because core attributes of the concept given as a cue are highly represented by word association, meaning that its associates might be seen as sharing a similarity and, as a consequence, might also have similar emotional values. Indeed, word association proved to be a very effective measure of word similarity. Van Rensbergen et al. (2016) found that the correlation between the ratings estimated by this method and those obtained from human participants was of an outstanding 0.91 for valence and 0.84 for arousal. This led the authors to conclude that this type of extrapolation methods could be useful to uncover psychological dimensions underlying word association (see also the dimensionality reduction techniques applied by Recchia and Lowrse, 2015, to estimate affective ratings for large datasets).

Following this line of reasoning, in the current report we provide an analysis of the relationship between the emotionality and degree of abstractness that brings together cue-associate pairs in three different large databases corresponding to three different languages: English (12,292 cues, De Deyne et al., 2019), Dutch (12,571 cues, De Deyne et al., 2013) and Spanish (5,423 cues, Fernández et al., 2018). If valence and arousal are represented in word association, we would expect to find that an associate's score on these dimensions can be effectively predicted by the same values of its cue. Following the same rationale, and considering previous studies showing how abstraction and association are related, we tentatively expected that concreteness would also be represented in word association.

Method

Instruments

English and Dutch word association data were obtained from the *Small World of Words* databases (De Deyne et al., 2019; De Deyne et al., 2013), each containing information on more than 12,000 cues presented to approximately 100 participants each. Spanish word association data were obtained from the *Spanish Free Association Norms* (Fernández et al., 2018), which contains associational data for nearly 6,000 cue words presented to at least 100 participants each. The English and Dutch databases include information on the first three associates (i.e., participants were told to respond to the cue with the first three words that came to mind), while for the Spanish database only the first associate was recorded. Therefore, for the sake of consistency, we used the data of only the first associate in both the English and Dutch databases.

Emotional ratings were gathered from Warriner et al. (2013) for English words (13,915 words), from Moors et al. (2013) for Dutch words (4,300 words) and from Stadthagen-Gonzalez et al. (2017) for Spanish words (14,031 words).

Finally, concreteness ratings were obtained from Brysbaert et al. (2014) for English words (40,000 words), from Brysbaert et al. (2014) for Dutch words (30,000 words) and from Duchon et al. (2013) for Spanish words (6,400 words).

Data Analysis

We began by matching each word in the three association databases with its respective emotional and concreteness values. This resulted in a total of 8,765 cues and 200,143 cue-associate pairs for the emotional values and 8,765 cues and 218,999 pairs for the concreteness values of English words, a total of 3,271 cues and 58,596 cue-associate pairs for the emotional values and 9,625 cues and 272,193 pairs for the concreteness values of Dutch words, and a total of 5,423 cues and 189,674 cue-associate pairs for the emotional values and 3,709 cues and 102,833 pairs for the concreteness values of Spanish words.

Then, piecewise linear regressions were conducted to predict the valence, arousal and concreteness of associate words. For each associate dimension, the first step of the piecewise regression included the other two dimensions not being predicted (e.g., arousal and concreteness as a first step to predict associates' valence), and the next step included the dimension being predicted (e.g., valence), the associative strength (i.e., the proportion of people that gave the same associate in response to a certain cue), as well as their interaction.

Results

Table 1 displays the goodness of fit between the two models used to predict the values of each dimension (valence, arousal and concreteness) in all three languages (English, Dutch and Spanish). Model 1 predicts the score on a specific dimension using the cue's scores on the other non-critical two dimensions. Model 2 adds the critical variable, the associative strength and the interaction between them. In all cases, the R^2 increases were statistically significant ($p < .001$).

- Insert Table 1 around here -

Table 2 displays the β coefficients of the best fit Model 2 in all three dimensions and languages. In all instances, the cues' values on the two dimensions not being predicted had little or no predictive power compared to the cues' values on the same dimension being predicted. The influence of the associative strength and its interaction with the cues' values on the predicted dimension can be best interpreted in Figure 1, which shows that it is a significant predictor and moderator of the effects: as the associative strength increases, negative cues result in more negative associates, while positive cues result in more positive associates.

- Insert Table 2 and Figure 1 around here -

Discussion

Van Rensbergen et al. (2016) showed that the emotional values of words could be accurately computed using association databases as similarity measures. This finding also brings to light the fact that valence and arousal are represented in word association, and the possibility that they can be critical mediating factors in the process. Furthermore, several studies provide solid evidence that abstract words are organized in word association networks in the mental lexicon (Crutch & Warrington, 2005; Crutch & Jackson, 2011; Duñabeitia et al., 2011; Barber et al., 2013), suggesting that concreteness could also be a key factor influencing the word association process. To prove these assumptions, we performed piecewise regression analyses in which we attempted to predict a word's score in each of these three variables (valence, arousal and concreteness) based on the values of the cues that preceded it. These analyses were carried out using three different word association databases: one in English (De Deyne et al., 2019), one in Dutch (De Deyne, et al., 2013) and one in Spanish (Fernández et al., 2018).

Across languages, our results showed that valence, arousal and concreteness values of associate words could be effectively predicted based on the values of their cues. We found that each word's dimension was better predicted by the cue's value on the same dimension (e.g., a cue's valence predicted its associates' valence better than arousal did). Moreover, we found that the strength of the association between two words modulated this predictive power, and that the stronger the association was, the more similar the cue and associate's values were. These findings suggest that valence, arousal and concreteness are indeed critical factors at play in word association, arguing against the proposition by Santos et al. (2011), who suggested that word association was mainly driven by simple lexical processes and word co-occurrence. In fact, the relationship between word co-occurrence and word association might actually be the opposite: when speaking or writing, we tend to use words that are emotionally congruent with the topic at hand (e.g., if we talk about a wedding, we may use words such as "love", "beautiful" or "cake", and if we talk about sewers, we may use words such as "stench", "rotten" or "rat"). Since we are more likely to use words with similar emotional values together, it would be plausible to assume that they are naturally more strongly associated with one another, making them more readily available when speaking, writing or signing. Following with the principles underlying Latent Semantic Analysis (see Deerwester et al., 1990), the current data suggest that one could predict that words that are used in similar contexts will show similar affective values through an analysis of the affective co-occurrence among lexical forms (e.g., Van Rensbergen et al., 2016).

The fact that word association reflects affective processes also has a possible implication for the affective priming phenomenon. Studies have found that the congruency between the valence of a prime and a target word quickens the RT in lexical decision tasks when both words are positive abstract items, but not when they are both positive concrete words (Yao & Wang, 2013, 2014) or negative words (Rosell & Nobre, 2004; Rosell et al., 2000; Sass

et al., 2012). Since abstract words seem to be organized in a word association complex (Crutch & Warrington, 2005; Crutch & Jackson, 2011; Duñabeitia et al., 2011; Barber et al., 2013), and the results of this study show that valence is a key factor in the word association process, it is likely that the visualization of an abstract word activates the representation of associates of a similar valence. Since positive words are generally processed faster than negative words (Kuperman et al., 2014; Scott et al., 2014), it is plausible that positive abstract primes activate a more extensive array of word associates than negative abstract primes would with negative word associates. This larger number of activated representations would, in turn, help quicken RT in primed lexical decision tasks, which would result in the observed affective priming effect. Furthermore, the fact that concreteness is also represented in word association suggests that it would be a good candidate variable to be extrapolated with the method devised Van Rensbergen et al. (2016).

The main limitation of this study is the lack of emotional and concreteness ratings for certain cues and —specially— associates, which means that we are not able to analyze the full range of cue-associate pairs of each database. This, however, should not detract for the present results, as the sample size is still remarkably large, and the words for which the emotional and concreteness values are absent tend to be weaker associates —words that have been given as an associate by only one person. In light of the current results, further research should test the viability of computationally extrapolating concreteness values through word association data, as well as applying this method to other languages. Additionally, more effort should be put into uncovering other possible variables and mechanisms that might underlie word association, as it could provide us with a clearer view on the way under which early abstract word processing operates. And finally, it would be worth exploring this same issue in significantly larger corpora in the same and other languages, in order to explore if the magnitudes of the observed

intra- and inter-language effects are partially due to the corpus size (see Brysbaert and New, 2009).

In summary, the present study demonstrated that, contrary to the assumption that word association is mainly mediated by lexical factors and simple word co-occurrence, the processes that relate word forms in the mental lexicon are clearly influenced by semantic and affective components, such as valence, arousal and concreteness. In fact, it may very well be possible that the influence of these mechanisms in word association is the cause of this word co-occurrence, and not the consequence. The remarkably reliable goodness of fit of the classification carried out on thousands of word pairs in three different languages demonstrates that affective factors are especially well-suited for the development of predictive computational models of word association. Hence, these results highlight the relevance of emotion-related constructs as mediating factors that determine the way in which words (and the underlying concepts) are represented in the human mind.

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Table 1*R² Comparisons Between Models*

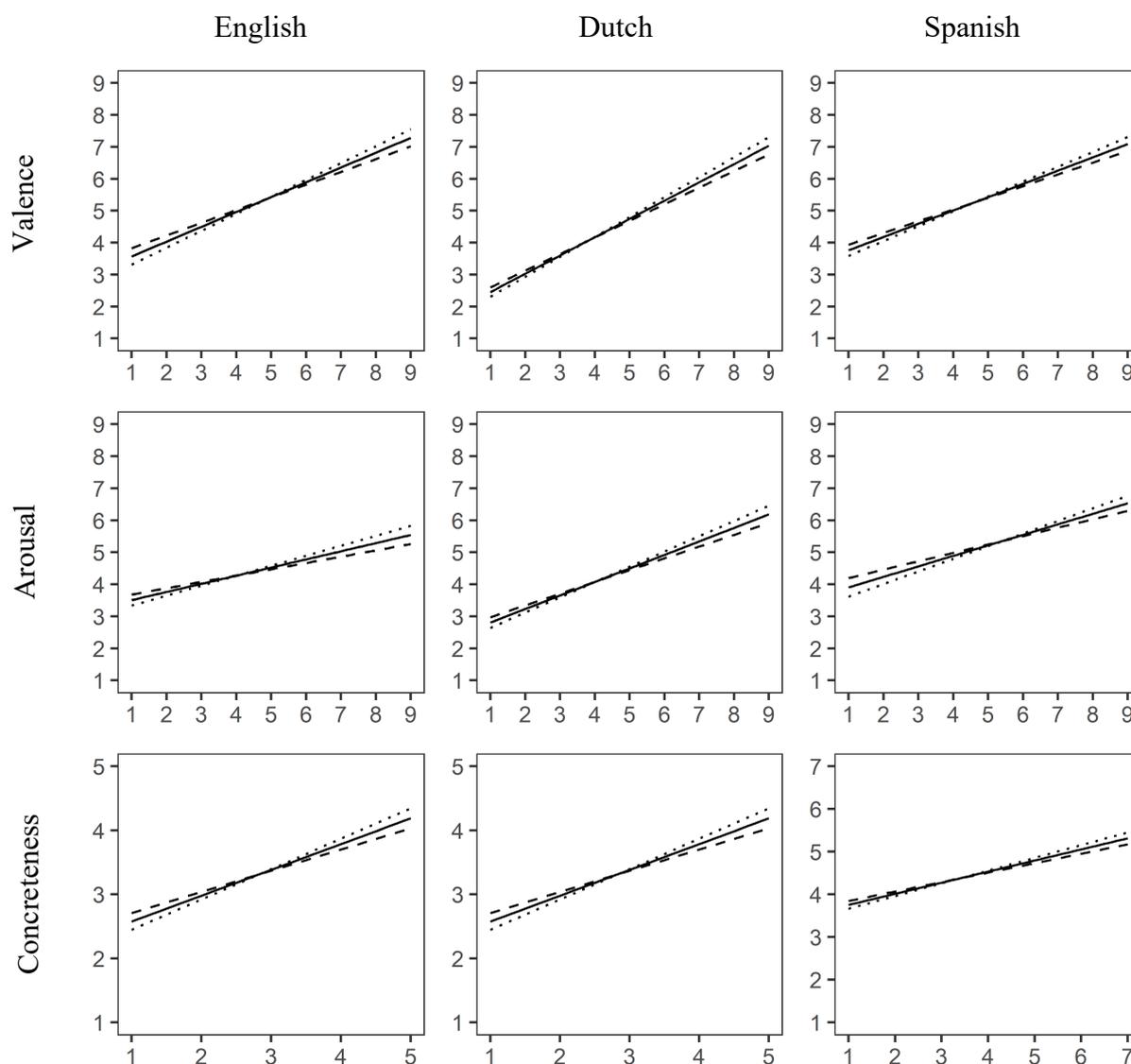
Associate dimension	Language	Model 1 R^2	Model 2 R^2	ΔR^2	df1	df2	F
Valence	English	.01	.17	.16	3	218993	14894.24
	Dutch	.01	.27	.26	3	58222	7313.65
	Spanish	.06	.15	.09	3	135239	5187
Arousal	English	.02	.07	.05	3	199350	4093.44
	Dutch	.01	.18	.17	3	58222	4098.05
	Spanish	.05	.12	.07	3	135239	3385.86
Concreteness	English	.01	.17	.16	3	218993	14894.24
	Dutch	.01	.24	.23	3	92370	9308.82
	Spanish	.01	.08	.07	3	102827	2659.86

Table 2

Full Linear Regressions Divided by Language and Dimension

Associate dimension	Predictor	English			Dutch			Spanish		
		β	SE	t	β	SE	t	β	SE	t
Valence	Intercept	3.27	0.023	139.05	1.96	0.031	63.21	3.81	0.045	84.20
	Valence	0.46	0.003	201.87	0.57	0.004	144.64	0.41	0.004	123.70
	Arousal	-0.06	0.002	-18.27	-0.03	0.003	-6.33	0.08	0.004	-18.84
	Concreteness	0.02	0.002	9.65	0.01	0.003	3.55	0.002	0.003	0.54 (NS)
	Strength	-0.16	0.06	-27.71	-0.10	0.007	-14.85	-0.11	0.09	-12.83
	Valence*Strength	0.03	0.001	30.41	0.03	0.002	16.01	0.02	0.002	15.77
Arousal	Intercept	3.64	0.016	221.82	2.47	0.024	100.36	4.12	0.031	130.38
	Valence	-0.04	0.001	-29.81	0.01	0.003	1.73	-0.06	0.002	-27.52 (NS)
	Arousal	0.25	0.002	106.87	0.42	0.003	-10.58	0.32	0.003	98.59
	Concreteness	-0.04	0.002	-21.55	-0.03	0.003	105.79	-0.04	0.003	-14.77
	Strength	-0.11	0.005	-24.30	-0.11	0.006	-18.61	0.18	0.008	-22.54
	Arousal*Strength	0.03	0.001	26.13	0.03	0.001	18.92	0.03	0.001	22.36
Concreteness	Intercept	2.27	0.015	143.38	1.95	0.023	83.99	4.01	0.033	121.11
	Valence	< 0.01	0.002	0.38 (NS)	-0.01	0.003	-4.18	-0.02	0.003	-9.93
	Arousal	-0.02	0.001	-10.65	-0.04	0.003	-11.76	-0.07	0.002	-20.62
	Concreteness	0.40	0.002	204.98	0.47	0.003	161.32	0.25	0.003	86.06
	Strength	-0.1	0.004	-27.84	-0.04	0.005	-7.88	-0.10	0.008	-8.58
	Concreteness*Strength	0.04	0.001	36.49	0.02	0.001	15.86	0.02	0.002	12.67

Note. NS = Non-significant.

Figure 1*Cue-Associate Regressions*

Note. The x-axes represent the value of the cue, while the y-axes represent the predicted value of the associate. The solid line represents the regression at the mean of the associate strength, while the dashed and dotted lines represent the regression at -1 SD and +1 SD from the mean, respectively.