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Research Article

The Effects of Emotional Valence and Arousal in the Free Recall of Serbian Nouns

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ABSTRACT

Recent studies demonstrated inconsistent patterns of results regarding emotional valence (EV) and arousal (A) in memorising words. According to the representational substitution hypothesis, emotions play a central role in representing abstract words, predicting a larger valence effect in the lexical processing of abstract words. Conversely, the multimodal induction hypothesis suggests that emotions may be more accessible for concrete words, as emotions can be readily evoked by activating relevant sensorimotor experiences. In our study, we tested these hypotheses through the incidental free recall task. During the implicit learning phase, 276 psychology students estimated different aspects (vividness of mental images associated with words, EV, and A) of the 64 Serbian nouns (32 concrete, 32 abstract). Concrete and abstract nouns were additionally divided into groups of positively and negatively valenced words that were either low or high in arousal. The stimuli were averaged for length, frequency, familiarity, age of acquisition, and context availability. The higher recall for positive words was recorded, regardless of concreteness, and for words with lower arousal. However, arousal had a distinct effect on abstract negative words, enhancing their recall. The concreteness effect was evident only for non-arousing negative words, highlighting the importance of sensory-based representations for less emotionally charged words during recall. These findings suggest that emotional experience plays a more critical role in representing abstract words, supporting the

representational substitution hypothesis. However, since we did not include neutral words, we cannot completely reject the multimodal induction assumption.

Keywords: emotional valence, arousal, concreteness, free recall

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Introduction

Many researchers nowadays accentuate words' emotional components, emphasising their importance for word processing and recall (Citron, Gray et al., 2014; Citron, Weekes, & Ferstl, 2014; Kousta et al., 2009; Russell, 2003). However, recent studies demonstrated inconsistent patterns of results regarding emotional valence and arousal and their effects on concrete and abstract word processing (Tornjanski, 2023; Tse & Altarriba, 2022).

It is important to distinguish between the effects of emotional valence and arousal on word processing and memorising. Since previous studies did not examine the independent effect of emotional valence and arousal on recall, we explored these effects in our study. Moreover, previous findings regarding the importance of emotions in representations of abstract and concrete words are inconsistent. Thus, words' concreteness, emotional valence, and arousal were manipulated, allowing the exploration of their separate and conjoint effects on recall.

Emotional valence and arousal of words

Emotional experience is typically defined by two primary dimensions: arousal and emotional valence (Russell, 2003). Emotional valence (EV) describes the extent to which a stimulus is positive or negative, while emotional arousal refers to intensity—whether the stimulus is exciting/agitating or calming/sedating (Citron, Gray et al., 2014; Citron, Weekes, & Ferstl, 2014; Feldman Barrett & Russell, 1998). Some researchers proposed that arousal cannot be independent of the emotional valence of stimuli (Watson et al., 1999). In contrast, some studies demonstrated the opposite by pointing out that more valenced (positive or negative) words are also more arousing than neutral words (Bradley & Lang, 1999; Citron, Weekes, & Ferstl, 2014), and negatively valenced words are more arousing than positively valenced words (Citron, Weekes, & Ferstl, 2014; Popović Stijačić et al., 2023). That is why controlling arousal in research on emotional valence is essential. In this paper, emotional valence and arousal were treated as independent factors; thus, we sampled those with high and low arousal within the groups of positive and negative words to explore their effects on recall.

Concreteness of words

Besides emotional valence and arousal, words' concreteness (i.e, the degree to which a word's meaning can be experienced by the senses) can vary as well. Previous studies showed that concrete words are recognised faster (Fliessbach et al., 2006) and reproduced more accurately than abstract words (Paivio, 1991; Popović Stijačić & Filipović Đurđević, 2022; Taylor et al., 2019). These advantages of concrete over abstract words have been referred to as *concreteness effects* and were found in various cognitive tasks, including paired associate learning, lexical decision, and free recall (Altarriba et al., 1999). We analysed this phenomenon from the perspective of dual coding theory (DCT; Paivio, 1991). The core structure of the DCT is the mental lexicon (verbal code) coupled with corresponding non-linguistic representations (non-verbal code) that contain mental images from all senses (e.g., Paivio, 1979, 1986, 2011). According to DCT, the concreteness effect can be explained by the fact that concrete words can be represented in both codes, verbal and non-verbal, and a greater number of associations later serve as an additional cue during retrieval. On the other hand, abstract words are represented only in verbal code, so they are typically less reproduced than concrete ones (Paivio, 1964).

Besides the DCT, there are also more linguistic approaches to the concreteness of words (Strik Lievers et al., 2021). For instance, the linguistic theory of concreteness explores the properties of words (their class, part of speech, mass or count, polysemy, etc.) and their relationship to concreteness. However, in this study, since the main research question was related to memory performance, concreteness was operationalized by a traditional DCT perspective.

Interaction of emotional valence and concreteness

Previous studies proposed different hypotheses and explanations about the effect of the interaction between emotional experience and words' concreteness on word processing, learning, and recall. Furthermore, previous research showed that emotional valence is differentially represented for concrete and abstract words. According to Embodiment theories, concrete words are fundamentally represented in sensorimotor

experiences of the physical world (Barsalou, 1999), while abstract words are more associated with situational events and introspective information, such as emotions (Barsalou, 2008). Unlike concrete words, abstract ones do not exist in space and time; their existence depends on human minds/language (Hale, 1988). Experiments that used fMRI demonstrated greater activation of the rostral anterior cingulate cortex during the visual recognition of abstract words (Vigliocco et al., 2014). This finding aligns with the hypothesis that abstract words may be primarily represented in emotional experiences and tend to be more emotionally valenced and arousing than concrete words (Kousta et al., 2011).

Research studies explored the interaction of EV and concreteness in recall (e.g., Tornjanski, 2023; Tse & Altarriba, 2022). Tse and Altarriba (2022) divided words into neutral, positively, and negatively valenced words, including emotion labels (e.g., *happy*, *hatred*) and emotion-laden words (e.g., *baby*, *jail*). Additionally, these groups of words were classified as concrete or abstract, while all were averaged for arousal. The dependent variable was the recall accuracy in the serial recall performance. They recorded the effect of emotional valence, where positive words had higher recall accuracy, regardless of concreteness, meaning that the interaction between concreteness and emotional valence was insignificant. The reproduction was lower when the level of arousal was higher. This research replicated the typical concreteness effect. In his study, Tornjanski (2023) manipulated words' emotional valence and concreteness while statistically controlling the arousal. Arousal was in the inverse proportion with word recall: low-arousing words were recalled more accurately than high-arousing words. The interaction between concreteness and emotional valence was significant, and concrete words were better recalled than abstract ones, but only in the group of negative words. There were no differences in recall of abstract and concrete words in the neutral and positive groups. This research did not replicate the concreteness effect, contrary to the findings of Tse and Altarriba (2022).

Although both studies controlled for arousal, these studies recorded different conjoint effects of concreteness, emotional valence, and arousal. Additionally, they used different memory tasks, cued recall (Tornjanski, 2023) and serial recall (Tse & Altarriba, 2022), respectively.

Our goal

The present study relied on two alternative views that explain the role of emotional valence in the lexical processing of concrete versus abstract words. Firstly, *the representational substitution hypothesis* suggests that emotions play a more central role in representing abstract words and predicts a larger valence effect in the lexical processing of abstract words since abstract words may be primarily grounded in emotional experiences (Yao et al., 2018). On the other hand, *the multimodal induction hypothesis* opposes this by suggesting that the EV has a more substantial relation with concrete words than abstract ones. It argues that emotions may be more accessible for concrete words, as emotions can be readily evoked by activating relevant sensorimotor experiences (Yao et al., 2018). This view relies on Embodiment theories, which predict that the representations of emotions are inherently multimodal and concrete words would engage highly interconnected sensory, motor, and affective systems (Niedenthal, 2007). Thus, according to these theories, a higher recall is expected for concrete emotional words than for abstract emotional words.

The present study aimed to test the above hypotheses (i.e., representational substitution and multimodal induction) through the implicit memory task. A factorial design was applied to explore how different arousal and emotional valence levels affect the recall of concrete and abstract words. If the emotional experience is more related to abstract words, then the different effects of the emotional experience are expected only in the group of abstract words. On the other hand, if the multimodal hypothesis is true, the different effects of the emotional experience should be recorded in both groups of words, with no interaction of concreteness and the emotional experience.

In line with DCT (Paivio, 1991), a better recall for concrete than abstract words was assumed. Further, we expected better recall for low-arousing words (Tornjanski, 2023). During incidental learning, participants estimated the vividness of mental images of words, emotional valence, or arousal of words. Based on previous research (Janković et al., 2023), we expected better recall for the words that participants estimated for a longer time, thus the most accurate reproduction for the group that rated the vividness of the mental images of the words. On the other hand, we hypothesised that

estimating the emotional dimensions would enhance the recall of words that primarily rely on the emotional experience.

Method

Participants

A total of 276 undergraduate students (31 males, 11.6%) from the Faculty of Media and Communications, Singidunum University, who are native Serbian speakers, participated in this experiment as part of the course requirements (M_{age} = 21.54, *SD* = 5.93). All participants signed informed consent forms confirming that they agreed with the researcher's explanation of the experimental procedure and its purpose. The research was approved by the Ethical Committee of the Faculty of Media and Communications.

Stimuli

The stimuli included 64 Serbian nouns collected from Popović Stijačić's normative study (2021). All words were averaged for length, objective frequency (Kostić, 1999)[1], familiarity, imageability, age of acquisition, and context availability. There were eight groups of nouns based on the level of concreteness, emotional valence, and arousal. Firstly, words were divided into two categories based on their level of concreteness (Paivio, 1968; Troche et al., 2017): 1) Concrete nouns (32 words) and 2) Abstract nouns (32 words). Further, words from each of those two categories were then divided into four subcategories based on their emotional experience (Citron Weekes, & Ferstl, 2014; levels of emotional valence and arousal): 1) Words with positive emotional valence and high level of arousal (EV+A+; arousing nouns associated with positive emotions; *pride*, *dance*); 2) Words with positive emotional valence and low level of arousal (EV+A-; calming nouns associated with positive emotions; *rest*, *beach*); 3) Words with negative emotional valence and high level of arousal (EV-A+; arousing nouns associated with negative emotions; *punishment*, *scream*); and 4) Words with negative emotional valence and low level of arousal (EV-A-; calming nouns

[1] The groups of words were additionally averaged by objective frequencies obtained from the srWaC – Serbian corpus from the web (Ljubešić & Klubička, 2016).

associated with negative emotions; *fatigue*, *swamp*). Each of those subcategories contained eight words.

As a criterion of the high and low emotional valence, we took the lower bound of the third tercile and the upper bound of the first tercile calculated on the whole sample of 2100 words from Popović Stijačić's norms (2021). Thus, words with a value higher than 4.62 were considered positively valenced, and those with a value lower than 3.82 were considered negatively valenced. The same was done for the high/low arousal criterion. Thus, words with a value greater than 4.63 were considered highly arousing, and those lower than 4.00 were non-arousing. The list of stimuli, with their psycholinguistic properties and descriptive statistics for the group of words, is presented in the Supplementary Materials (Table E).

Procedure

The experiment was conducted online, and all the data were collected within three days. Participants accessed the test from their computers using the *SoSci Survey* platform (Leiner, 2021). Participants were randomly assigned to experimental situations that differed from each other regarding the first task – the word estimation. There were three experimental groups regarding the type of estimation: 1) The vividness group (V; *N*=89) estimated the vividness of mental images of words; 2) The emotional valence group (*N*=93) estimated how much words can be associated with positive or negative emotions; and 3) The arousal group (*N*=85) estimated how much words are calming or arousing. Each participant assessed the same list of 64 nouns and eight filler words (four at the beginning and four at the end of the list), controlling the *serial position effect* (Murdock, 1962). All nouns were estimated on a five-point Likert scale (1 – words that are easily imagined almost as if they were visible in reality, totally calming, and associated with negative emotions; 3 – neutral words according to the type of assessment; 5 – words that are: not imaginable at all, totally agitating, and associated with positive emotions).

After the word rating task, participants did the mental rotation task (Ganis & Kievit, 2015), which lasted approximately 5–7 minutes. Finally, they did the incidental free recall task in which they were required to write every remembered word from the list of nouns they previously estimated into the

blank spaces. The time for this task was limited to five minutes, and participants did not have the option to finish it earlier. After the time expired, participants were asked if they used any of the mentioned memorising strategies by choosing one or more offered answers: association with words or their meanings, creating mental images associated with the words, putting the words into meaningful groups and relying on the emotional experience of words while recalling.

Design

We used a three-factor design in which we manipulated the type of word estimation between subjects and within items in the incidental learning phase. This factor had three levels: imaginability estimation, arousal estimation, and emotional valence estimation. Furthermore, we manipulated the concreteness of words (concrete and abstract words) and the emotional experience (arousal and emotional valence of words, EV+A+, EV+A-, EV-A+, EV-A-) within subjects and between items. The dependent variable was recall accuracy (coded 0 for incorrect and 1 for correct recall).

Data analysis

We used a three-factor design in which we manipulated the type of word estimation between subjects and within items in the incidental learning phase. This factor had three levels: imaginability estimation, arousal estimation, and emotional valence estimation. Furthermore, we manipulated the concreteness of words (concrete and abstract words) and the emotional experience (arousal and emotional valence of words, EV+A+, EV+A-, EV-A+, EV-A-) within subjects and between items. The dependent variable was recall accuracy (coded 0 for incorrect and 1 for correct recall).

The data were analysed with R statistical software (R Core Team, 2021) and modelled with mixed effects logistic regression using the *lme4* package (Bates et al., 2015), which allows the modelling of random effects and is a more appropriate analysis of variables with binary outcomes (Jaeger, 2008; Popović Stijačić et al., 2018). Baar's recommendation (Baar et al., 2013) for modelling the structure of random effects was applied (thus using the structure justified by the study's design). However, the model selection was data-driven; therefore, the model with the best-fit indices (highest AIK

and lowest log Likelihood) that converged and did not have a singular fit was kept. All the data and R code are available on the OSF repository (Popović Stijačić & Protić, 2025).

Results

A logistic mixed effect model was fitted to predict the accuracy of incidental free recall. The model that contained the interaction of all fixed effects was significantly better than the model without the interaction (χ^2 (17) = 35.97, p = .005; AIC = 14320):

$$response \sim ass * conc * EE + (1 \mid ID) + (1 \mid word)\dagger$$

† ass - assessment; conc - concreteness; EE - emotional experience; ID - subject ID;

The model included random intercepts of participants (formula: ~ 1 | ID) and random intercepts of words (1 | word). A more complex random structure was not adopted due to the problem of either convergence or overfitting. The model was further trimmed for residuals that exceeded 2.5 of standard error, which improved the model performance (AIC = 11510). The variance decomposition of random effects is presented at the bottom of Table 1. The explanatory power of the fixed effects was R^2= .12 (marginal R^2), and for the whole model, R^2 = .54 (conditional R^2).

The estimates of the fixed effect coefficients are also presented in Table 1. Since the intercepts of the model are set to abstract words, arousing positive words, and assessment of the vividness, we used post hoc comparison to check the differences between all the relevant categories (see Table B, C, and D in the Supplementary Materials). We recorded significantly lower recall for the group of negative non-arousing words (E-A-) compared to the group of positive arousing abstract words (E+A+; B = -1.68; z = -2.00, p = .045). Post hoc analysis (Tukey) revealed that recall was significantly higher for the positive non-arousing words compared to the negative non-arousing ones (z = 2.75, p = .03), regardless of the concreteness group. The main effect of concreteness was not recorded: (B = -1.68; z = 1.12, p = .26).

Within negative abstract words, those with higher arousal had greater recall accuracy (the difference in recall accuracy between E-A+ and E-A-

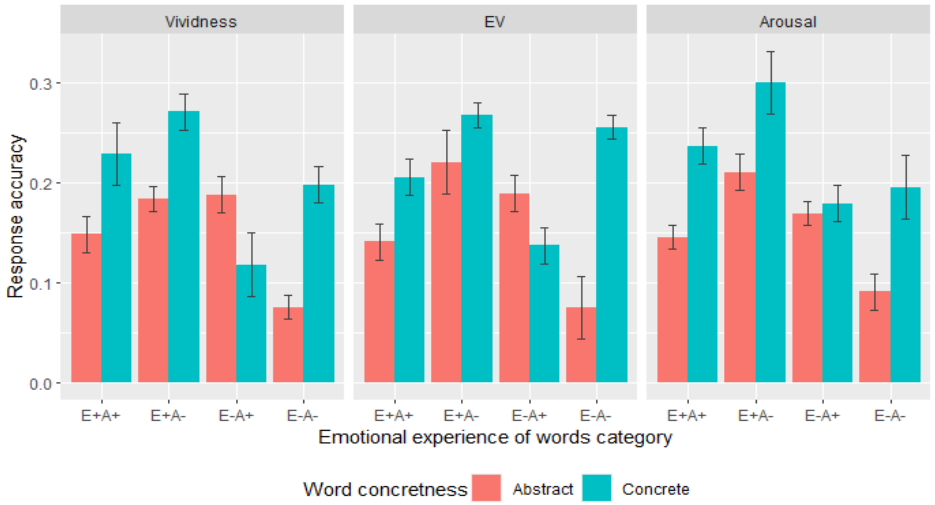
groups: z = 2.67, p = .037), meaning that higher arousal contributed to the recall accuracy of the abstract words. The abstract positive non-arousing words were recalled significantly better than the abstract negative arousing words (E+A- and E-A+ difference: z = 2.73, p = .032). Within concrete words, there was no significant difference in recall regarding the emotional experience of words.

There was an interaction between the concreteness and the emotional experience of words, meaning that the concreteness effect was recorded only in the group of negative non-arousing words (z = - 2.92, p = .003).

Further analyses revealed a significant triple interaction between the assessment group, concreteness, and emotional experience (Tables C and D in the Supplementary Materials). We found that the recall of the positive abstract non-arousing words was significantly better than the recall of the negative arousing abstract words in all three assessment groups. Within the groups of abstract negative words, those with higher arousal had greater recall accuracy compared to those with lower arousal when students rated vividness and emotional valence but not arousal (Table C in the Supplementary Materials). On the other hand, there were no significant effects of the emotional experience in the group of concrete words regardless of the assessment group. The mean recall accuracy based on the factors of the assessment, concreteness, and emotional experience of words is presented in Figure 1.

Figure 1

Mean Proportion of Correct Recall by Emotional Experience and Concreteness of Words, Clustered by Estimation Group



Note. The vertical bars denote 95% confidence intervals of the mean accuracy

Table 1

The Fixed Effects Estimates with the Fit Indices of the Model and the Random Effects Structure of the Mixed Logit Model

Predictors	Estimate	*SE*	*z* value	*p*
(Intercept)	-2.964	.575	-5.155	.000
Ass EV	-.110	.223	-.496	.620
Ass A	-.056	.227	-.247	.805
Concrete words	.893	.794	1.124	.261
EV+A-	.373	.802	.466	.641
EV-A+	.631	.799	.789	.430
EV-A-	-1.683	.840	-2.005	**.045**
Ass EV: Concrete w	-.175	.244	-.716	.474
Ass A: Concrete w	.090	.246	.367	.714

Ass EV: EV+A-	.530	.247	2.157	**.031**
Ass A: EV+A-	.343	.252	1.363	.173
Ass EV: EV-A+	.114	.244	.469	.639
Ass A: EV-A+	-.157	.251	-.626	.531
Ass EV: EV-A-	-.109	.346	-.315	.753
Ass A: EV-A-	.401	.329	1.219	.223
Concrete w: EV+A-	.360	1.117	.322	.748
Concrete w: EV-A+	-1.931	1.127	-1.713	.087
Concrete w: EV-A-	1.359	1.153	1.178	.239
Ass EV: Concrete w: EV+A-	-.311	.319	-.974	.330
Ass A: Concrete w: EV+A-	-.212	.324	-.654	.513
Ass EV: Concrete w: EV-A+	.656	.351	1.873	.061
Ass A: Concrete w: EV-A+	1.130	.353	3.204	**.001**
Ass EV: Concrete w: EV-A-	.995	.408	2.439	**.015**
Ass A: Concrete w: EV-A-	-.450	.398	-1.13	.258
Random effects				
σ^2	3.29			
$\tau_{00\ ID}$	.62			
$\tau_{00\ word}$	2.43			
Observations	16624			
Marginal R^2	0.118			
Conditional R^2	0.543			

Note. Intercept is set to abstract word, assessment of vividness, and EV+A+ emotional experience. Ass EV - assessment of emotional valence; Ass A - assessment of arousal; Concrete w - concrete words; CI - confidence intervals; Marginal R^2 - R^2 for the model with only fixed effects; Conditional R^2 - R^2 for the model with both fixed and random effects; σ^2 – overall variance of random effects; $\tau_{00\ ID}$ – variance of the random intercept from the participants; $\tau_{00\ word}$ – variance of the random intercept from the words.

Discussion

This study explored the influence of emotional experience related to concrete and abstract words in free recall, aiming to shed light on the debate about whether emotional experience is particularly relevant for representations of abstract words. Two views were contrasted (i.e., the representation substitution and the multimodal induction hypothesis; Yao et al., 2018), and several effects were tested: the emotional experience effect, the concreteness effect, the effect of the implicit learning task, and their interactions.

In line with previous studies (Tornjanski, 2023; Tse & Altarriba, 2022), a higher recall of the positively valenced words, regardless of concreteness, and more accurate recall of the words with lower arousal were recorded (Tornjanski, 2023). This advantage of positive word recall is usually explained by Pollyanna's Principle (Boucher & Osgood, 1969), according to which most people have a tendency toward pleasant stimuli. However, the lower recall accuracy for arousing stimuli is harder to explain, especially knowing that those stimuli are recognised faster in word processing tasks (i.e., the arousal has a facilitative effect; Kousta et al., 2011).

A significant interaction between emotional experience and concreteness was observed as (1) the different effects of emotional experience in each group and (2) the selective concreteness effect, present only in the negative non-arousing group of words. Concerning the first observation, within abstract negative words, we noted that non-arousing words had lower recall accuracy than arousing words. This suggests arousal enhanced the reproduction of negative abstract nouns, serving as an additional cue that helped their retrieval. Such differences were not recorded in the group of concrete words. Regarding the second observation, like in Tornjanski's study (2023), the interaction between emotional experience and concreteness was obtained, with the concreteness effect noted only in the non-arousing negative group of words. The lack of the emotional experience effect in the group of concrete words aligns with the representational substitution hypothesis. However, the selective concreteness effect observed only in the negative, non-arousing group remains unexplained.

However, our results, along with Tornjanski's findings (2023), contradict the studies and theories that emphasise the role of arousal in memory retrieval (Kensinger, 2009). Our results are partially in line with the findings of Adelman and Estes (2013). They used the Big Data approach and recognition task on 2500 words and found only the effect of emotional valence but not the effect of arousal. Thus, our results showed that arousal enhanced the recall only for abstract negative words. If the negative arousing words automatically drive attention, greater recall accuracy would be expected for such stimuli, regardless of the concreteness.

Several theoretical perspectives emphasise the interaction between recall retention and arousal. One such perspective is the perseverative consolidation hypothesis (Kleinsmith & Kaplan, 1963), which argues that recall retention duration interacts with arousal. According to this hypothesis, high-arousal words have an advantage over low-arousal words in long-term retention, whereas low-arousal words are recalled better in immediate or short-delay conditions.

Concerning the emotional valence, Kensinger (2009) argued that negative stimuli are more connected to the activation of the brain regions engaged in sensory-motor processing (visual cortex and fusiform gyrus), while positive stimuli are related to the regions involved in semantic and conceptual processing (lateral prefrontal and temporal regions). We hypothesised that such a pattern of results could be explained by the engagement of the visual brain regions during the mental rotation task, which was administered between the learning and retrieval phases. In other words, the activation of sensory regions during the pause could have prevented the memory consolidation of negative words.

Although the incidental learning tasks were designed to promote the activation of sensory-motor information (assessment of vividness) or emotional information (assessment of emotional valence and arousal), no recall advantage was observed for concrete negative words when vividness was rated, nor for positive words when valence or arousal was assessed.

In this study, arousal was varied as an independent factor instead of only being statistically controlled, as was the case in previous studies (Tse & Altarriba, 2022; Tornjanski, 2023). All words were averaged for length, objective frequency, familiarity, imageability, age of acquisition, and context

availability. Additionally, by redirecting participants' attention towards specific semantic facets, we were able to investigate whether prioritizing the sensory or emotional aspect would contribute to differences in word reproduction relative to concreteness or emotional experience.

The absence of a neutral word group precludes us from drawing a comprehensive conclusion regarding the acceptance of the multimodal induction hypothesis. Additionally, the current study noted a generally low recall accuracy, suggesting that future research should be conducted without an inserted pause between incidental learning and reproduction.

Conclusion

Our research showed that emotional experience and word concreteness contribute to abstract and concrete word recall: a greater recall for positive words and those with low arousal was recorded. These results align more with the representational substitution hypothesis, according to which emotional experience is more relevant for representations of abstract words. Emphasising the sensory or emotional processes during the implicit learning phase, we did not detect differences in the recall of concrete or abstract words. One possible explanation for the lack of the potential boosting effect of the sensory process during retrieval is that participants paused between learning and recalling while doing mental rotation tasks, which put a load on visual processing. Future studies should explore this possibility by utilising a pause without a task or testing immediate recall.

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Conflict of interest

We have no conflicts of interest to disclose.

Data availability statement

The data from this study, along with the R statistical codes, are available on the author's OSF page (link to the OSF repository).

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Supplementary Materials

Table A

Descriptive statistics of the words, grouped by concreteness and emotional experience

Variables	Emotional experience	Word concreteness	Mean	Std. Deviation	N
logF	EV+A+	Abstract	4.124	1.045	8
		Concrete	4.22	1.773	8
		Total	4.172	1.407	16
	EV+A-	Abstract	4.683	1.36	8
		Concrete	4.7	1.072	8
		Total	4.692	1.183	16
	EV-A+	Abstract	4.244	.892	8
		Concrete	4.138	1.025	8
		Total	4.191	.93	16
	EV-A-	Abstract	3.396	1.174	8
		Concrete	3.6	1.889	8
		Total	3.498	1.523	16
	Total	Abstract	4.112	1.173	32
		Concrete	4.165	1.473	32
		Total	4.138	1.321	64
Length	EV+A+	Abstract	6.25	1.035	8
		Concrete	6.125	1.356	8
		Total	6.188	1.167	16
	EV+A-	Abstract	5.875	1.458	8
		Concrete	6.625	1.847	8
		Total	6.25	1.653	16
	EV-A+	Abstract	5.5	1.414	8
		Concrete	6	2.07	8
		Total	5.75	1.732	16
	EV-A-	Abstract	6.75	1.909	8

		Concrete	5.875	1.356	8
		Total	6.313	1.662	16
		Abstract	6.094	1.489	32
	Total	Concrete	6.156	1.629	32
		Total	6.125	1.548	64
		Abstract	3.22	.641	8
	EV+A+	Concrete	5.272	.751	8
		Total	4.246	1.257	16
		Abstract	2.912	.63	8
	EV+A-	Concrete	5.615	.705	8
		Total	4.263	1.538	16
		Abstract	3.072	.525	8
Concreteness	EV-A+	Concrete	5.356	.895	8
		Total	4.214	1.376	16
		Abstract	3.118	.707	8
	EV-A-	Concrete	5.748	.683	8
		Total	4.433	1.515	16
		Abstract	3.08	.608	32
	Total	Concrete	5.498	.751	32
		Total	4.289	1.394	64
		Abstract	3.835	1.214	8
	EV+A+	Concrete	5.459	1.132	8
		Total	4.647	1.41	16
		Abstract	3.926	1.578	8
	EV+A-	Concrete	5.997	.784	8
		Total	4.961	1.61	16
Imageability		Abstract	3.304	.768	8
	EV-A+	Concrete	5.576	1.019	8
		Total	4.44	1.462	16
		Abstract	3.701	.487	8
	EV-A-	Concrete	5.912	.941	8
		Total	4.806	1.352	16

	Total	Abstract	3.691	1.068	32
		Concrete	5.736	.956	32
		Total	4.714	1.44	64
Emotional valence	EV+A+	Abstract	5.964	.366	8
		Concrete	5.899	.488	8
		Total	5.931	.418	16
	EV+A-	Abstract	5.509	.881	8
		Concrete	5.917	.488	8
		Total	5.713	.72	16
	EV-A+	Abstract	2.518	.377	8
		Concrete	2.614	.441	8
		Total	2.566	.399	16
	EV-A-	Abstract	2.953	.423	8
		Concrete	3.106	.289	8
		Total	3.03	.359	16
	Total	Abstract	4.236	1.629	32
		Concrete	4.384	1.612	32
		Total	4.31	1.609	64
Arousal	EV+A+	Abstract	5.034	.664	8
		Concrete	5.431	.492	8
		Total	5.232	.601	16
	EV+A-	Abstract	3.174	.471	8
		Concrete	3.023	.502	8
		Total	3.098	.477	16
	EV-A+	Abstract	5.645	.398	8
		Concrete	5.387	.409	8
		Total	5.516	.412	16
	EV-A-	Abstract	3.341	.599	8
		Concrete	3.664	.226	8
		Total	3.502	.468	16
	Total	Abstract	4.298	1.199	32
		Concrete	4.376	1.147	32

		Total	4.337	1.164	64
		Abstract	5.159	.52	8
	EV+A+	Concrete	5.388	.916	8
		Total	5.274	.729	16
		Abstract	5.228	.717	8
	EV+A-	Concrete	5.46	1.009	8
		Total	5.344	.854	16
		Abstract	4.909	.884	8
Familiarity	EV-A+	Concrete	4.857	1.048	8
		Total	4.883	.937	16
		Abstract	5.284	.567	8
	EV-A-	Concrete	4.85	1.155	8
		Total	5.067	.907	16
		Abstract	5.145	.669	32
	Total	Concrete	5.139	1.026	32
		Total	5.142	.859	64
		Abstract	5.364	.34	8
	EV+A+	Concrete	5.922	.707	8
		Total	5.643	.608	16
		Abstract	5.191	.674	8
	EV+A-	Concrete	5.988	.649	8
		Total	5.59	.76	16
		Abstract	5.078	.284	8
Context availability	EV-A+	Concrete	5.235	.581	8
		Total	5.156	.449	16
		Abstract	5.254	.422	8
	EV-A-	Concrete	5.158	.613	8
		Total	5.206	.511	16
		Abstract	5.222	.445	32
	Total	Concrete	5.576	.72	32
		Total	5.399	.62	64
AoA	EV+A+	Abstract	6.634	1.24	8

	Concrete	7.658	2.943	8
	Total	7.146	2.245	16
	Abstract	7.536	2.156	8
EV+A-	Concrete	5.915	2.104	8
	Total	6.726	2.222	16
	Abstract	7.878	1.555	8
EV-A+	Concrete	6.425	1.886	8
	Total	7.151	1.83	16
	Abstract	7.233	.805	8
EV-A-	Concrete	6.288	1.797	8
	Total	6.76	1.431	16
	Abstract	7.32	1.518	32
Total	Concrete	6.571	2.22	32
	Total	6.946	1.924	64

Table B

Multiple comparisons (Tukey correction) by concreteness and emotional experience averaged by the assessment group

Group level	contrast	groups	estimate	SE	df	z.ratio	p.value
abstract	E+A+	E+A-	-.8983	.788	Inf	-.843	.834
	E+A+	E-A+	-.9114	.788	Inf	-.782	.865
	E+A+	E-A-	1.7688	.818	Inf	1.939	.212
	E+A-	E-A+	-.0131	.792	Inf	-060	.999
	E+A-	**E-A-**	**2.2595**	**.822**	**Inf**	**2.73**	**.028**
	E-A+	**E-A-**	**2.2018**	**.822**	**Inf**	**2.67**	**.027**
concrete	E+A+	E+A-	-.850	.783	Inf	-1.084	.699
	E+A+	E-A+	.719	.790	Inf	.911	.799
	E+A+	E-A-	.045	.791	Inf	.057	.999
	E+A-	E-A+	1.569	.788	Inf	1.99	.192
	E+A-	E-A-	.895	.789	Inf	1.134	.668
	E-A+	E-A-	-.674	.794	Inf	-.848	.831
E+A+	abstract	concrete	-.865	.783	Inf	-1.104	.269
E+A-	abstract	concrete	-1.05	.785	Inf	-1.337	.181
E-A+	abstract	concrete	.471	.792	Inf	.594	.552
E-A-	**abstract**	**concrete**	-2.405	.822	**Inf**	-2.926	.003

Table C

Multiple Comparisons (Tukey correction) of the recall of abstract words and concrete for EE categories for the assessment of Vividness, Emotional valence, and Arousal

Comparison of the recall of abstract words for EE categories for the assessment of Vividness

contrast		estimate	SE	Df	z.ratio	p.value
EV+A+	EV+A-	-.3734	.801	Inf	-.466	.9664
EV+A+	EV-A+	-.6309	.799	Inf	-.789	.8594
EV+A+	EV-A-	1.6828	.839	Inf	2.005	.1861
EV+A-	EV-A+	-.2575	.803	Inf	-.321	.9886
EV+A-	EV-A-	2.0561	.844	Inf	2.437	.0703
EV-A+	**EV-A-**	2.3136	.843	Inf	2.744	.0309

Comparison of the recall of abstract words for EE categories for the assessment of EV

contrast		estimate	SE	Df	z.ratio	p.value
EV+A+	EV+A-	-.9032	.8	Inf	-1.129	.6718
EV+A+	EV-A+	-.7451	.801	Inf	-.93	.7885
EV+A+	EV-A-	1.7917	.845	Inf	2.12	.1468
EV+A-	EV-A+	.1581	.801	Inf	.197	.9973
EV+A-	**EV-A-**	2.6949	.846	Inf	3.185	**.0079**
EV-A+	**EV-A-**	2.5368	.847	Inf	2.995	**.0146**

Comparison of the recall of abstract words for EE categories for the assessment of A

contrast		estimate	SE	Df	z.ratio	p.value
EV+A+	EV+A-	-.7161	.802	Inf	-.893	.8087
EV+A+	EV-A+	-.4734	.803	Inf	-.589	.9353
EV+A+	EV-A-	1.2815	.837	Inf	1.531	.4185
EV+A-	EV-A+	.2426	.804	Inf	.302	.9905
EV+A-	EV-A-	1.9976	.838	Inf	2.384	.0802
EV-A+	EV-A-	1.7549	.839	Inf	2.091	.1561

Comparison of the recall of concrete words for EE categories for the assessment of Vividness

contrast		estimate	SE	Df	z.ratio	p.value
EV+A+	EV+A-	-.7329	.792	Inf	-.926	.7911
EV+A+	EV-A+	1.3002	.805	Inf	1.614	.3705
EV+A+	EV-A-	.3242	.801	Inf	.405	.9776
EV+A-	EV-A+	2.0331	.803	Inf	2.531	.0553
EV+A-	EV-A-	1.0571	.798	Inf	1.325	.5472
EV-A+	EV-A-	-.976	.811	Inf	-1.203	.6248

Comparison of the recall of concrete words for EE categories for the assessment of EV

contrast		estimate	SE	Df	z.ratio	p.value
EV+A+	EV+A-	-.9518	.793	Inf	-1.201	.6263
EV+A+	EV-A+	.5296	.802	Inf	.66	.9119
EV+A+	EV-A-	-.5617	.799	Inf	-.703	.8961
EV+A-	EV-A+	1.4814	.799	Inf	1.855	.2478
EV+A-	EV-A-	.3901	.796	Inf	.49	.9613
EV-A+	EV-A-	-1.0913	.804	Inf	-1.357	.5267

Comparison of the recall of concrete words for EE categories for the assessment of A

contrast		estimate	SE	Df	z.ratio	p.value
EV+A+	EV+A-	-.8638	.792	Inf	-1.09	.6955
EV+A+	EV-A+	.3273	.799	Inf	.41	.9768
EV+A+	EV-A-	.373	.802	Inf	.465	.9666
EV+A-	EV-A+	1.1911	.796	Inf	1.495	.4402
EV+A-	EV-A-	1.2367	.799	Inf	1.548	.4085
EV-A+	EV-A-	.0456	.805	Inf	.057	.9999

Table D

Multiple comparisons (Tukey correction) Abstract and Concrete pairs by Assessment and Emotional Experience

Assessment	Emotional experience	Difference	Estimate	SE	df	z.ratio	p.value
Vividness	E+A+	Ab-Conc	-.893	.794	Inf	-1.124	.2608
	E+A-	Ab-Conc	-1.252	.795	Inf	-1.575	.1152
	E-A+	Ab-Conc	1.038	.808	Inf	1.285	.1989
	E-A-	Ab-Conc	-2.251	.843	Inf	-2.671	**.0076**
Emotional valence	E+A+	Ab-Conc	-.718	.797	Inf	-.901	.3676
	E+A-	Ab-Conc	-.766	.793	Inf	-.966	.3339
	E-A+	Ab-Conc	.557	.804	Inf	.693	.4884
	E-A-	Ab-Conc	-3.071	.845	Inf	-3.634	**.0003**
Arousal	E+A+	Ab-Conc	-.983	.797	Inf	-1.234	.2173
	E+A-	Ab-Conc	-1.131	.794	Inf	-1.423	.1546
	E-A+	Ab-Conc	-.182	.803	Inf	-.227	.8204
	E-A-	Ab-Conc	-1.892	.839	Inf	-2.256	**.0241**

Table E

The stimuli list, with the means on the control variables

WORD	Conc cat	EE cat	logf	Len	Con	Img	EV	Arous	Fa	CA	AoA
PONOS	1.00	1.00	4.86	5.00	2.07	2.56	6.06	4.75	5.63	5.47	8.44
DOBITAK	1.00	1.00	3.37	7.00	2.72	3.35	6.35	5.94	5.18	5.27	7.60
ZNANJE	1.00	1.00	5.03	6.00	3.24	3.35	5.82	4.33	5.75	5.59	6.44
REKORD	1.00	1.00	4.45	6.00	3.44	3.41	5.65	4.71	4.67	5.61	7.00
BLAGO	1.00	1.00	4.86	5.00	3.94	6.59	5.35	4.63	5.56	4.89	5.08
NAGRADA	1.00	1.00	5.05	7.00	3.94	4.26	6.47	6.00	5.39	5.82	4.68
DIVOTA	1.00	1.00	2.89	6.00	3.53	3.32	5.89	4.47	4.29	4.88	6.91
AVANTURA	1.00	1.00	2.48	8.00	2.88	3.84	6.12	5.44	4.81	5.39	6.92
POVERENJE	1.00	2.00	4.83	9.00	2.00	2.47	5.80	3.33	6.35	4.53	7.64
SVRHA	1.00	2.00	4.74	5.00	2.29	2.00	5.17	3.82	4.82	4.67	9.16
SVEMIR	1.00	2.00	4.56	6.00	2.41	5.65	4.44	3.53	4.78	5.18	7.84
IDILA	1.00	2.00	1.79	5.00	2.71	3.24	6.39	2.94	4.35	5.24	10.44
ODMOR	1.00	2.00	5.09	5.00	3.35	4.16	6.59	2.44	5.81	5.65	5.51
JESEN	1.00	2.00	6.72	5.00	3.50	6.41	4.13	3.47	5.35	6.19	4.08
NEŽNOST	1.00	2.00	5.16	7.00	3.50	4.71	6.00	3.22	5.82	5.82	6.20
SKLAD	1.00	2.00	4.57	5.00	3.53	2.78	5.56	2.63	4.53	4.26	9.42
NEMIR	1.00	3.00	5.97	5.00	2.44	3.37	2.00	6.06	4.82	5.06	7.48
PREVARA	1.00	3.00	3.64	7.00	3.11	2.59	2.13	6.06	5.12	5.44	8.08
KAZNA	1.00	3.00	4.92	5.00	3.69	3.39	2.53	5.18	6.18	5.06	4.96
KAJANJE	1.00	3.00	3.81	7.00	2.61	2.41	2.24	5.47	4.88	4.79	8.52
PRKOS	1.00	3.00	4.09	5.00	2.65	2.89	3.00	5.47	3.63	4.63	8.28
OPTUŽBA	1.00	3.00	3.71	7.00	2.88	3.26	2.61	5.50	4.06	5.00	8.66
BES	1.00	3.00	4.63	3.00	3.89	4.89	2.65	6.19	6.06	5.24	6.76
POROK	1.00	3.00	3.18	5.00	3.31	3.63	3.00	5.24	4.53	5.41	10.28
DOSADA	1.00	4.00	4.20	6.00	2.12	3.42	2.82	2.27	6.50	5.89	5.74
SLABOST	1.00	4.00	4.79	7.00	3.75	3.84	2.61	2.63	5.33	5.18	6.92
MOLBA	1.00	4.00	5.12	5.00	3.82	3.33	3.17	3.88	5.22	5.71	8.08
ZAMOR	1.00	4.00	2.56	5.00	3.29	4.37	3.06	3.26	4.65	5.19	7.48
GAŠENJE	1.00	4.00	2.71	7.00	3.78	4.28	3.11	3.44	5.31	5.50	6.52
OZBILJNO	1.00	4.00	2.94	10.00	3.00	3.53	3.75	3.88	5.33	5.06	7.36
NERAD	1.00	4.00	1.79	5.00	3.12	2.94	2.75	3.76	5.24	4.63	7.68
BOLOVANJ	1.00	4.00	3.04	9.00	2.06	3.89	2.35	3.61	4.69	4.88	8.08
STRAST	2.00	1.00	5.84	6.00	4.71	3.71	6.06	5.79	5.11	6.39	11.16
LETO	2.00	1.00	6.19	4.00	5.00	6.47	6.24	5.35	6.69	6.41	3.96
RITAM	2.00	1.00	4.87	5.00	5.29	5.11	5.82	4.88	5.94	5.58	7.32
KONCERT	2.00	1.00	5.92	7.00	5.82	5.89	6.24	5.88	5.37	6.50	6.54
IGRANKA	2.00	1.00	3.78	7.00	4.29	5.67	5.75	5.18	4.00	4.71	8.16
SMEJANJE	2.00	1.00	3.47	8.00	6.17	6.82	6.59	5.53	6.33	6.56	4.00
PASOŠ	2.00	1.00	2.08	5.00	6.29	6.06	5.06	4.72	5.25	6.12	8.04
EROTIKA	2.00	1.00	1.61	7.00	4.60	3.94	5.44	6.12	4.41	5.11	12.08
SVITANJE	2.00	2.00	5.45	8.00	5.29	5.94	5.71	2.74	5.25	5.88	7.36
JEZERO	2.00	2.00	5.83	6.00	5.35	6.88	5.17	3.11	4.38	6.06	5.08
MILOVANJE	2.00	2.00	4.04	9.00	5.47	5.11	6.38	3.16	4.88	5.59	6.68

PLAŽA	2.00	2.00	3.30	5.00	5.67	6.79	5.94	2.33	5.71	6.50	4.89
PRIJATEL	2.00	2.00	5.94	9.00	5.71	5.58	6.76	3.89	6.88	6.41	4.72
GITARA	2.00	2.00	3.89	6.00	6.33	6.32	5.94	3.50	5.94	6.06	5.56
KREVET	2.00	2.00	5.46	6.00	6.72	6.58	5.88	2.61	6.60	6.75	3.03
OAZA	2.00	2.00	3.69	4.00	4.38	4.78	5.56	2.84	4.06	4.67	10.00
METAK	2.00	3.00	5.23	5.00	5.59	6.17	2.53	5.47	4.35	5.28	7.24
BUKA	2.00	3.00	4.09	4.00	5.83	6.63	3.12	5.71	5.88	5.65	4.84
OTROV	2.00	3.00	4.75	5.00	5.94	5.12	2.33	4.82	4.59	6.05	5.92
PAUK	2.00	3.00	4.67	4.00	6.65	6.44	3.29	5.32	6.13	5.33	3.76
VRISAK	2.00	3.00	4.94	6.00	5.65	6.00	2.84	6.13	4.31	4.89	5.36
GLAVOBOLJA	2.00	3.00	2.08	10.00	4.94	5.58	2.18	5.47	5.83	5.70	6.40
VEŠALA	2.00	3.00	3.97	6.00	4.25	5.22	2.06	5.19	3.00	4.67	9.48
NEPOGODA	2.00	3.00	3.37	8.00	4.00	3.44	2.56	5.00	4.76	4.31	8.40
IGLICA	2.00	4.00	3.14	6.00	5.63	6.16	2.78	3.94	3.39	4.82	4.98
MOČVARA	2.00	4.00	3.66	7.00	5.71	6.29	2.88	3.67	3.29	4.55	6.92
SPOMENIK	2.00	4.00	5.19	8.00	6.06	6.06	3.12	3.84	5.88	5.06	8.04
SIVILO	2.00	4.00	1.39	6.00	4.59	5.68	2.71	3.33	4.44	4.75	7.36
OPUŠAK	2.00	4.00	1.79	6.00	6.38	6.26	3.28	3.76	4.39	5.35	7.96
BARA	2.00	4.00	3.99	4.00	6.19	6.28	3.22	3.82	5.50	4.81	4.00
KOPIJA	2.00	4.00	2.48	6.00	4.94	3.72	3.44	3.59	5.47	5.44	7.40
KIŠA	2.00	4.00	7.16	4.00	6.50	6.84	3.44	3.35	6.44	6.47	3.64

Note: Conc cat – 1 abstract, 2 concrete word; EE cat – 1 E+A+, 2 – E+A-, 3 – E-A+, 4 – E-A-; Con – mean concreteness; CA – mean context availability; Len – length of word; logf – logarithm of word frequency; Fa – familiarity; AoA – age of acquisition.