# Are Emojis Processed Visuo-Spatially or Verbally? Evidence For Dual Codes

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**Abstract**

Emojis have become a pervasive aspect of modern communication in digital mediums. While some argue that emojis are processed similar to words, opponents note dissimilarities. It remains unclear whether encoding and later remembering emojis, relative to words, engages primarily verbal or visuo-spatial cognitive functions. To address this question, we used a divided attention (DA) technique to infer similarities and differences in how words and emojis are represented and retrieved from memory. We compared the magnitude of interference (measured as decline in memory output) experienced when participants freely recalled a list of studied target words or emojis under dual-task conditions with a concurrently performed distracting task. Participants encoded either target words or emojis (between-subjects) under full attention (FA), and later recalled them under FA or while concurrently performing a 1-back task that required processing words (DA Words), emojis (DA Emojis), or novel star shapes (DA Stars), manipulated within-subjects. Memory for emojis was higher overall compared to words. Recall of words was unaffected by the DA Stars condition, but significantly worse in the DA Words, and to a lesser degree in the DA Emojis condition, relative to FA. In line with past studies, these results suggest that memory for words relies primarily on reactivation of verbal representations, which is hampered when the distracting task also requires verbal, but not visuo-spatial, processing. In contrast, small but significant declines in recall were observed for emojis across all DA conditions relative to FA. Results suggest that unlike words, representation and retrieval of emojis engages both verbal and visuo-spatial processing.

*Keywords:* emoji, memory, dual-task, verbal, visuo-spatial

**Are Emojis Processed Visuo-Spatially or Verbally? Evidence For Dual Codes**

Emojis are ideograms (i.e., graphic symbols) used in digital communication to represent both concrete and abstract concepts (Rodrigues et al., 2018). In the absence of face-to-face interaction, online communicators often use emojis to disambiguate their expressions and convey semantic information (Riordan, 2017). Some suggest that as our digital society evolves, emojis may be becoming language-like (Bai et al., 2019), akin to adjectives or modifiers of words (Alshenqeeti, 2016). That is, emojis can transform plain texts into expressive and vivid messages, making text-based communication less ambiguous and more efficient (Tauch & Kanjo, 2016). As is the case with multi-word expressions, emojis also have semantic functionality independent of text; emojis that are often literal in interpretation can be combined to express more subtle semantics (López & Cap, 2017). For instance, emojis representing a frog and a hot beverage are sometimes combined (i.e., 🐸☕) and used as a postscript following a passive aggressive statement online, roughly translatable to 'but that's none of my business', referencing the fictional character Kermit the Frog pictured in a popular ad for tea (López & Cap, 2017). Furthermore, 89% of emoji strings created to convey semantic information can be translated into text correctly by at least one untrained individual, with 47% of translations both correct and similar across two different untrained interpreters (Khandekar et al., 2019).

Others, however, suggest parallels between emojis and Chinese character writing and ancient pictographic language systems (e.g., Egyptian hieroglyphics; Alshenqeeti, 2016). Some academics in the linguistic community consider emojis as a revival of hieroglyphic language (Ghenţulescu, 2016), akin to logographic scripts that are pictographic in form. Ancient Chinese and Egyptians used symbols and pictures, instead of an alphabet-based language, to communicate with others and record history (Scoville, 2015; Wong, 2018). Emojis lack some essential linguistic traits; they contain neither grammatical structures, characters, nor letters. Grammar keeps components of a sentence in order. When words in an English sentence are arranged in different positions, the meaning of the sentence changes (Debata, 2013). At least when interpreted literally, rearranging a series of emojis does not necessarily provide readers with different meanings (Cohn, 2015). Moreover, many regard emojis as 'digital gestures' rather than words (Gawne & McCulloch, 2019). For instance, emojis like '🍎' are illustrative gestures that we use to refer to concrete objects, emojis like '👈' are deictic gestures that we use to explain directions and locations (McNeill, 1992), and emojis like '☺️' are illocutionary gestures used to express intent (Kendon, 2004). Specifically, some view emojis as a paralanguage, similar to components of non-lexical speech such as gestures that combine with language to form multi-modal communication (McCulloch & Gawne, 2018). Indeed, research suggests that emojis serve as effective tools to supplement text with affect and personality trait information, comparable to human facial expressions (Boutet et al., 2021).

Given the use of emojis to improve reading comprehension (Riordan, 2017), and inquiries into the potential for them to become an independent language, questions have arisen as to whether emojis are processed comparably to written words in terms of cognitive engagement. For instance, emojis and words elicit similar event-related potential (ERP) response patterns when their function is to induce irony at sentence-end positions, as well as to replace nouns in sentences; this suggests that emojis are integrated into sentences in a manner comparable to words when they are aligned with top-down expectations conveyed by the context of a sentence (Weissman, 2019; Weissman & Tanner, 2018). In line with these ERP findings, eye-tracking studies show a similar temporal sequence of semantic processing for both words and emojis when they were added to the ends of sentences (Barach et al., 2021). As well, individuals can retrieve phonological representations of emojis when they serve as homophones: For instance, when the palm tree emoji (🌴) is used to mean the palm of a hand (Scheffler et al., 2022).

Other research, however, notes dissimilarities between word and emoji processing, both when emojis are presented in isolation and within a sentence context. Self-paced reading times are longer when emojis replace verbs or nouns in sentences, likely reflecting a processing cost due to switching modalities (Cohn et al., 2018; Gustafsson, 2017; Scheffler et al., 2022). However, these substitutions do not interfere with the comprehensibility of sentences (Cohn et al., 2018; Scheffler et al., 2022). Additionally, in a lexical decision task, both pictures of emotional human faces and emojis (presented in isolation) have been shown to elicit shorter response latencies as compared to emotional words, implying that emojis, like faces, may be more efficient than words at conveying affective information (Kaye et al., 2021). Finally, electroencephalogram (EEG) evidence has shown different neural activation patterns during the semantic processing of words and emojis. Results suggest that the neural activity engaged for semantic processing of emojis and words differs, not only in theta power oscillation patterns, but also in the neuronal network related to certain processes associated with comprehension (Tang et al., 2021). Such patterns suggest words and emojis differ in terms of how they are represented, as well as how these regions connect with other brain processing regions. Overall, the literature has thus far demonstrated that emojis may be processed similarly or dissimilarly to words, depending on both the context in which they are placed, as well as the specific cognitive activities being examined.

It is important to consider that emojis could be inherently distinct from words in terms of bottom-up encoding processes, while still being used similarly to words when top-down contextual processing is needed. For instance, emojis can serve a 'rebus' function, wherein they can form or fit into a sentence based on their phonological labels (e.g., '👁❤️NY' = 'I love New York'; Scheffler et al., 2022). Emojis can also alter the overall meaning of sentences in which they are used, by modifying tone (e.g., 'I just had my date with Joe [😊/ 😞]'; Weissman, 2019). Finally, the meanings of emojis, separate from their phonological labels, can also be used in sequences to form phrases that refer to abstract concepts (e.g., '⏰🐷 ✈️' = 'when pigs fly'; Khandekar et al., 2019).

**Current Study**

In the current study we used a divided attention, or dual-task, technique to infer similarities and differences in how words and emojis are processed. The logic in such studies is that by comparing conditions in which attention is divided between a target and distracting task, one can infer by disruption in performance, relative to a non-distracted condition, whether concurrent tasks require similar processing resources or representational systems. Decrements in performance, termed 'interference effects', manifest because a common cognitive system, and/or brain area(s), is being overly taxed (Friedman et al., 1982; Kinsbourne & Hicks, 1978; Klingberg, 1998; Klingberg & Roland, 1997). For example, in seminal work within the area of short-term memory, Pellegrino, Siegel, and Dhawan (1976) used this logic to assess whether short-term memory was differentially affected by distraction, depending on whether the encoded information was verbal (words) or visual (pictures). Results showed that acoustic distraction led to a larger reduction in short-term memory for words than for pictures, whereas visual distraction led to the opposite outcome, such that performance reductions were larger in memory for pictures. Thus, a dual-task paradigm can be used to infer the codes that are used to represent and retrieve target items in memory. Using this technique, Fernandes and Moscovitch (2000) similarly showed that significant levels of interference occurred when the materials in the distracting and target long-term memory tasks overlapped. In that work, during episodic recall of a set of previously studied words, participants simultaneously performed either a digit-based or equally difficult word-based distracting task. The digit-based task produced a small detriment to the recall of studied words (13% reduction from full attention; comparable to that reported by others; Anderson et al., 1998; Craik et al., 1996). In contrast, a word-based task produced a more substantial 30% decrease in word recall performance. Such a pattern was believed to have occurred because memory for words required access to the same representational system as did the word-based, but not the digit-based, distracting task.

As another example, Fernandes and Guild (2009) examined whether episodic memory retrieval of words and spatial patterns was affected differently by concurrently performed distracting tasks, differing only in type of processing required for each: phonological or visuo-spatial. They showed that memory for words compared to spatial grid patterns was differentially disrupted depending on whether the distracting task required visuo-spatial or phonological processing. Based on the double dissociation observed in that study, the authors suggested that visuo-spatial and verbal episodic memories require reactivation of qualitatively different types of codes. More recently, again using a similar logic and paradigm to the one used in our current study, Wammes and Fernandes (2016) inferred the processes critical for episodic retrieval of faces by measuring susceptibility to memory interference from different distracting tasks. There they showed that configural more so than featural processing disrupted memory for faces. Work such as this contributes to the larger literature on divided attention, suggesting specialized subsystems for maintaining visuo-spatial and verbal information (Baddeley, 1986; Baddeley et al., 1975; Farmer et al., 1986; Logie et al., 1990). Importantly, these past studies show how the dual-task logic can be used to infer which representational and processing systems are engaged by different types of target materials.

As in these past studies, here we used the dual-task technique to infer representational and processing requirements for words and emojis presented in isolation, to determine whether they are the same or different. We compared memory performance when participants freely recalled a list of target words, or target emojis, under dual-task conditions with one of three different distracting tasks, relative to a full attention (FA) condition (within-subjects). In each of the three divided attention (DA) conditions, participants freely recalled either words or emojis (between-subjects) out loud whilst simultaneously completing a 1-back task to a different set of words (DA Words), a different set of emojis (DA Emojis), or a set of novel star shapes (DA Stars). We hypothesized that word recall performance would be most impaired in the DA Words condition and least impaired in the DA Stars condition, in line with past studies (Fernandes et al., 2004, 2005, 2006, 2013; Fernandes & Guild, 2009; Fernandes & Moscovitch, 2000, 2002, 2003). That is, because memory for words requires verbal-based cognitive processing, it should be most impaired when the distracting task also requires the same verbal system (DA Words), and less affected by a purely visuo-spatial distracting task requiring processing of patterns within star shapes (DA Stars). We also hypothesized that memory for words would be impaired in the DA Emojis condition if indeed emojis engaged verbal processing. Importantly, if emojis are similar to words in terms of their representational and cognitive processing requirements, then the pattern of interference should be similar for both types of stimuli. If, however, emojis are processed like images or other visuo-spatial materials, then we would expect relatively little interference when recalling emojis in the DA Words condition, and greater interference in the DA Stars condition. It is important to note that we did not compare the processing of words and emojis in terms of top-down capability as modifiers within sentences (e.g., Barach et al., 2021; Weissman & Tanner, 2018). Instead, we examined the underlying representational code invoked during single item presentation and retrieval from memory.

We were also interested in examining whether English language competency, or frequency of emoji use in daily life, correlated with the number of words or emojis recalled overall. We reasoned that those who frequently use emojis in their daily lives might be more likely to engage verbal processing when retrieving emojis, and hence show greater interference when retrieving emojis during the DA Words condition, as the emojis would be processed akin to verbal material. We reasoned that those who report low usage of emojis would instead process emojis as visuo-spatial material, and therefore demonstrate little interference in the DA Words condition, but more in the DA Stars (visuo-spatial) condition.

# Method

The procedures and materials for this study were approved by the Office of Research Ethics at the University of Waterloo (ORE #42234). Our pre-registration for this study, along with all materials, experiment files, data, and statistical code can be found on the Open Science Framework (OSF: https://tinyurl.com/yw3u2cau)

## Participants

Our goal was to observe effects of retrieval condition within each memory material group (words or emojis), as the critical comparisons were between the different divided attention (DA) at retrieval conditions relative to full attention (FA). Before data collection began, we conducted an a priori power analysis based on a similar study in which DA effects at retrieval were considered (Craik et al., 1996). This analysis indicated that a minimum of 39 participants were needed per memory material group to detect a medium to large effect size ($d_z$ = 0.60) between two dependent-group means (FA to DA) with 95% power and alpha set at .05 (two-tailed).

We collected data from 90 undergraduate students from the University of Waterloo, all of whom self-selected to participate in the study (42 in the words group and 48 in the emojis group) in exchange for course credit. Participants were excluded from analyses if they scored less than 30% on Set A of the Mill-Hill vocabulary scale (Raven, 1958), indicating low English competency, leading to the exclusion of one participant in the words group, and three participants in the emoji group. The final sample therefore consisted of 41 participants (33 female) in the words group, ranging in ages from 18 to 27 ($M$ = 21.1, $SD$ = 2.2), and 45 participants (27 female) in the emoji group, ranging in ages from 18 to 36 ($M$ = 20.7, $SD$ = 3.1). Eligible participants self-reported on a pre-screen questionnaire to have learned English before the age of 8 (used to ensure language competency), and to have normal or corrected-to-normal vision and hearing.

## Materials

### *Target Word and Emoji Encoding Stimuli*

For the word encoding task, 45 concrete nouns were selected from the Affective Norms for English Words (ANEW) database (Bradley & Lang, 1999), spoken aloud by a female and recorded using the Apple Voice Memos application on an iPhone 11, saved as separate audio files. Four randomized lists of 10 words each were created for use in the experimental phase, and one five-word list was created for the practice phase. Word stimuli lists were matched to each other on average valence, arousal, number of letters, and frequency (see Table 1). See OSF for the metrics of valence, number of letters, arousal, and frequency for each individual word list.

**Table 1**
*Valence, Arousal, Number of Letters, and Frequency of to-be-remembered Words*

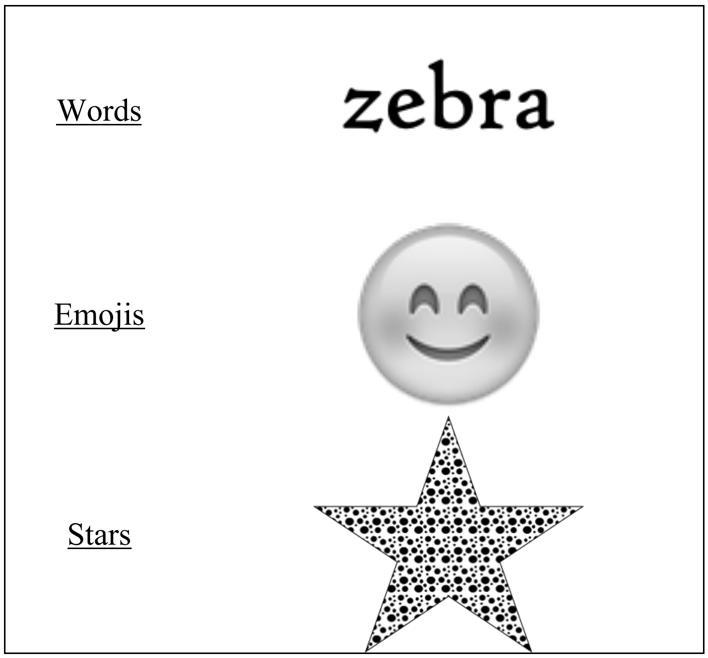
| Characteristic | *M* | *SD* | Range |
|---|---|---|---|
| Valence | 5.9 | 1.0 | 2.76–7.96 |
| Arousal | 4.5 | 0.9 | 3.18–7.38 |
| Number of letters | 5.3 | 1.0 | 3–8 |
| Frequency | 62.7 | 80.5 | 1–348 |

For the emoji recall task, 45 emojis were sourced from the online Emojipedia website (https://emojipedia.org/). To create the emoji lists, we substituted each word in the word lists with a semantically similar emoji. For example, the word 'cake' in word List A was replaced with the birthday cake emoji in List A for the emoji group. We chose exclusively iOS emojis as research suggests these are more familiar, meaningful, and clear compared to those found on other operating systems (Rodrigues et al., 2018). All emoji images were converted to greyscale and re-sized to 72x72 pixels (Rodrigues et al., 2018).

***Word, Emoji, and Star Distracting Task Stimuli***

Items in the word-based distracting task (DA Words) were 40 animal names selected from the norms of valence, arousal, and dominance for 13,915 English lemmas database (Warriner et al., 2013). All words used in this task were presented in one of 10 different fonts, with no font used in two consecutive trials in order to prevent participants from matching words based on shape. For the star-based distracting task (DA Stars), a single basic geometric star shape was created using PowerPoint, then 40 variations were made such that they maintained a consistent outer shape but contained differing internal fill patterns. Emojis used in the emoji-based distracting task were 40 facial expression iOS emojis, all sourced from the Lisbon Emoji and Emoticon Database (Rodrigues et al., 2018). Distracting task stimuli were intentionally created to represent the same semantic category in order to ensure the 1-back task was sufficiently difficult: Emojis were all facial expressions, words were all animals, and stars all shared the same outer shape. Finally, matching the format of to-be-remembered stimuli in the emoji group, all emojis and star images were presented in greyscale on a white background, re-sized to 72x72 pixels (see Figure 1 for samples).

**Figure 1**
*Samples of the Stimuli Used in the 1-back Distracting Task for Words, Emojis, and Stars*




***Language Competency and Emoji Use Frequency***

English language competency was assessed using Set A of the Mill-Hill Vocabulary Scale (Raven, 1958). Emoji use was measured with a novel 5-item inventory (see questionnaire on OSF), intended to measure the propensity to which participants would use emojis in different contexts (Items 1 through 4), as well as in general (Item 5), with responses scored on a 7-point scale from 1 (*not at all likely*) to 7 (*extremely likely*). Both scales were administered electronically via Qualtrics.

**Procedure**

Participants completed the experiment on their personal computer during a 1-on-1 videoconference with the researcher that lasted approximately 45-minutes. The session was consensually recorded to collect and tabulate memory output performance (spoken free recall). Stimulus presentation and response recording were controlled by OpenSesame experiment builder software (Mathôt et al., 2012), hosted on a local university server using the JATOS experiment manager (Lange et al., 2015). To-be-remembered material was manipulated between-subjects: Data were collected from all the participants in the words group, followed by all the participants in the emoji group over the course of seven months.

After providing informed consent, participants completed a practice 1-back task using uppercase letters to orient them to the requirements of the distracting tasks without giving an advantage to a specific condition. The practice section consisted of 10 trials. For each trial, participants saw a letter presented for 1750 ms followed by a fixation cross for 250 ms. Participants were asked to respond as quickly and accurately as possible when they saw a letter appear on the screen that matched the previous letter by pressing the 'm' key on their keyboard with their dominant hand. When two consecutive items were distinct, no response was required. There were three affirmative trials in total during this practice section.

Following the distracting task practice phase, a baseline measure of performance on each of the three distracting tasks was gathered. Depending on the task, words, emojis, or stars were used as the stimuli presented on-screen. For each condition, participants completed a 1-back task, consisting of 30 trials, within which 10 items were repeated consecutively and therefore required an affirmative response from participants. The instructions and presentation rate were identical to that in the practice 1-back task. For each of the three 1-back conditions (words, emojis, or stars), two different 30-item lists were created; one list was used in the baseline task procedures, and the other in the DA task administered at retrieval, with list order counterbalanced between-subjects.

After gathering baseline distracting task performance data, participants completed a practice version of the encoding and recall task. Those in the words group heard a female voice reading a list of five words at a rate of one word per 1750 ms followed by 250 ms of silence. Participants in the emoji group saw five emojis presented on-screen, at a rate of one emoji per 1750 ms followed by a fixation cross for 250 ms. Participants were asked to commit the words or emojis to memory. Following the encoding phase, a short delay of 20 seconds occurred in which participants were instructed to complete a filler task (counting backwards aloud from 99 by threes to prevent recency effects; as in Craik et al., 1996). In the practice retrieval phase, participants were then given 30 seconds to freely recall aloud the words or verbal descriptions of emojis that they remembered.

Participants then completed four study-recall cycles. While the order of target stimuli lists remained consistent (Lists A, B, C, and D, in that order), the order of retrieval conditions (i.e., FA, DA Words, DA Stars, and DA Emojis) was partially counterbalanced across subjects such that there were four different orders of the retrieval conditions, with each retrieval condition having a 25% chance of appearing in a particular position of the sequence (see OSF for detailed information on order groups). In each study-recall cycle, encoding of either words or emojis was always performed under full attention. The presentation rate and subsequent filler task were identical to that in the practice phase. In the FA retrieval condition, participants were asked to recall aloud, in any order, the words or emojis they could remember from that study phase, within a time limit of 60 seconds. In each of the three DA conditions, participants freely recalled either words or emojis out loud whilst simultaneously completing either a word- (DA Words), emoji- (DA Emojis), or star-based (DA Stars) distracting 1-back task. Participants were asked to place equal effort on performing both tasks when in a DA recall phase. A two-minute break followed each study-recall cycle in which participants played an online Pac-Man game with the sound muted (https://pacman.live).

Following all four study-test cycles, participants completed the Mill-Hill assessment (Raven, 1958) and our emoji use questionnaire. Participants in the emoji group then completed an additional emoji labelling task, in which they were asked to 'type the first label that comes to mind' for all 45 emojis used in the experiment, which were presented sequentially on the screen one at a time. The original intent of the labelling task was to use the emoji labels generated by each participant to score their recall (as emoji labels can differ between individuals). Some participants, however, opted to use different labels for the same emoji in the recall and labelling tasks, rendering this method of scoring ineffective.

## Results

All statistical analyses were conducted using SPSS (version 28).

### Number of Words or Emojis Recalled

The number of words or emojis recalled was tabulated (see Table 2). Recall of emojis required participants to say aloud a label or description of each emoji they remembered. As emoji labels can differ between participants, emoji recall was assessed by two coders, both unaware of any a priori hypotheses. Each coder independently judged whether a participant correctly recalled an emoji using transcribed audio of the participant's free recall, blind to the recall conditions to avoid possible biases. The total number of correctly recalled emojis in each condition, from each participant, was the average of the scores assigned by both coders. Interrater reliability was excellent ($r$ = .95).

**Table 2**

*Number of Items Recalled in Each Condition, for Each Material Group (Words or Emojis)*

| Material group and condition | Words group ($n$ = 41) | | Emojis group ($n$ = 45) | |
|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* |
| FA | 5.3 | 2.0 | 6.5 | 1.7 |
| DA words | 3.9 | 2.3 | 5.5 | 1.7 |
| DA emojis | 4.6 | 2.3 | 5.9 | 1.9 |
| DA stars | 5.1 | 2.0 | 5.6 | 2.0 |

*Note.* FA = full attention. DA = divided attention. Ten words or emojis were presented in each Condition, for each Group.

We conducted a 2 (Material: emojis or words; between-subjects) X 4 (Condition: FA, DA Words, DA Emojis, DA Stars; within-subjects) mixed analysis of variance (ANOVA)[1] with number of items recalled as the dependent measure. There was a significant main effect of Material, $F(1, 84) = 12.16$, $MSE = 9.72$, $p < .001$, $\eta_p^2 = .13$, such that overall emojis were better remembered than words. As expected, there was also a significant main effect of Condition, $F(3, 252) = 9.50$, $MSE = 2.05$, $p < .001$, $\eta_p^2 = .10$. The Material X Condition interaction, however, was non-significant, $F(3, 252) = 1.93$, $MSE = 2.05$, $p = .13$, $\eta_p^2 = .02$.[2] Given our strong a priori hypotheses regarding differential effects of retrieval condition in each group, we conducted separate one-way repeated measures ANOVAs for each Material group, with Condition as the manipulated factor and number of items recalled as the dependent measure.

For the words group, there was a significant main effect of Condition, $F(3, 120) = 6.63$, $MSE = 2.31$, $p < .001$, $\eta_p^2 = .14$. Planned simple effects contrasts revealed that memory was

[1] We originally included retrieval condition Order as a 4-level, between-subjects factor in the ANOVA. The main effect of Order was non-significant ($p = .393$). We therefore collapsed across this factor in subsequent analyses but note that the pattern of results reported here is comparable as to when Order was included.

[2] We also conducted Bayesian analyses. We used the BayesFactor (Morey et al., 2011) package for *R* to calculate the Bayes factor for the interaction, enlisting a default Jeffreys-Zellner-Siow (JZS) prior with a Cauchy distribution (center = 0, $r = 0.707$), and comparing to a null model that included both main effects as well as subject-level error. The Bayes factor provided only moderate evidence for the null effect of the interaction, $BF_{10} = 1/6.16$.

significantly worse in the DA Words condition compared to FA, $F(1, 40) = 19.60$, $MSE = 4.04$, $p < .001$, $\eta_p^2 = .33$. There was also a small but significant decline in memory in the DA Emojis condition compared to FA, $F(1, 40) = 4.65$, $MSE = 4.41$, $p = .04$, $\eta_p^2 = .10$. The number of words recalled in the DA Stars condition did not differ from that in the FA condition $F(1, 40) = 0.53$, $MSE = 4.64$, $p = .47$, $\eta_p^2 = .01$.

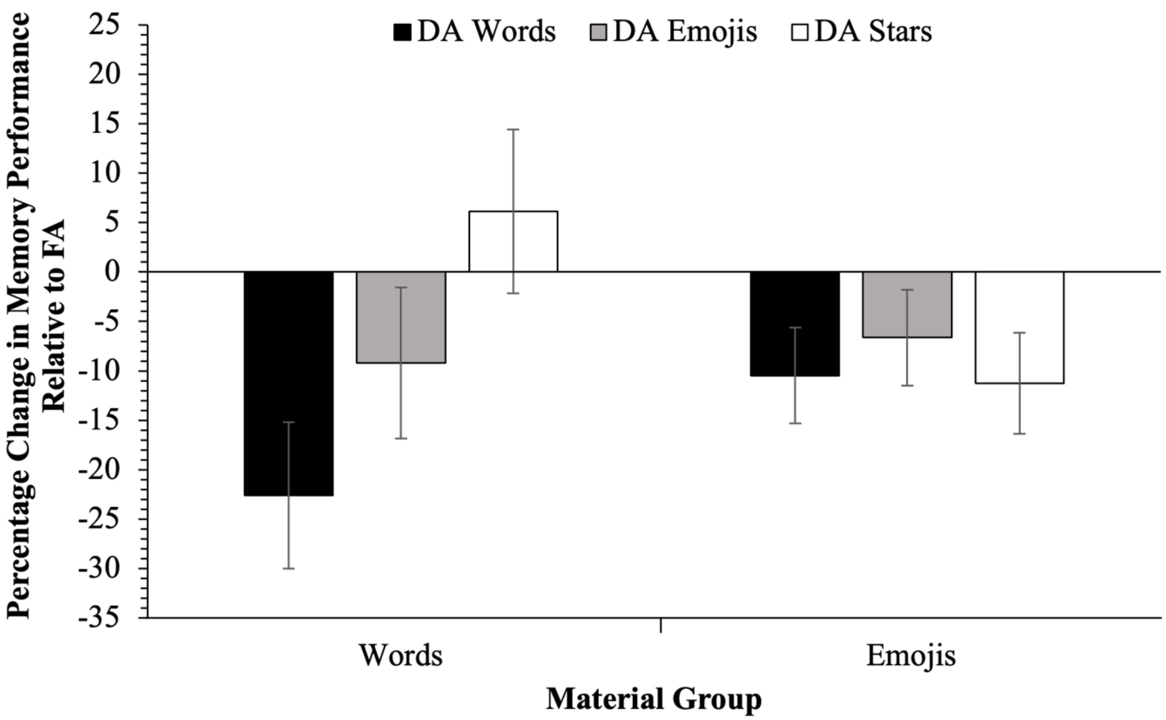
In the emoji group, there was also a main effect of Condition $F(3, 132) = 4.27$, $MSE = 1.81$, $p = .01$, $\eta_p^2 = .09$. Planned simple effects contrasts revealed small but significant declines in memory across all DA conditions relative to FA: DA Words, $F(1, 44) = 8.70$, $MSE = 4.51$, $p = .01$, $\eta_p^2 = .17$, DA Emojis, $F(1, 44) = 4.75$, $MSE = 2.92$, $p = .04$, $\eta_p^2 = .10$, and DA Stars, $F(1, 44) = 8.11$, $MSE = 3.65$, $p = .01$, $\eta_p^2 = .16$.

**Memory Interference**

To determine if the amount of memory interference differed between DA conditions (all relative to FA), we also conducted ANOVAs using the percentage change in performance from full attention as the dependent measure. This was calculated as the number of words recalled in the DA condition minus that recalled in the FA condition, and this value was then divided by the number of words recalled under FA, then multiplied by 100 to reflect a percentage decline value (see Figure 2).

**Figure 2**

*Percentage Change in Memory from Full Attention (FA) to Divided Attention (DA) Conditions*




*Note.* Percentage change was calculated as [(DA – FA)/FA]*100. DA Words, DA Emojis, and DA Stars refer to retrieval conditions with distracting tasks using words, emojis, and stars, respectively. Error bars represent standard error of the mean.

The main effect of Condition, $F(2, 168) = 4.81$, $MSE = 936.11$, $p = .01$, $\eta_p^2 = .05$, as well as the Condition X Material interaction, $F(2, 168) = 4.89$, $MSE = 936.11$, $p = .01$, $\eta_p^2 = .06$ were significant. The main effect of Material was non-significant, $F(1, 84) = 0.01$, $MSE = 3475.14$, $p = .93$, $\eta_p^2 = .00$. To understand the interaction, we conducted separate one-way ANOVAs for each Material group. For memory of words, there was a main effect of Condition, $F(2, 80) = 6.03$, $MSE = 1403.79$, $p < .01$, $\eta_p^2 = .13$. Pairwise comparisons revealed that interference in the DA Words condition did not differ significantly from that in the DA Emojis condition, $p = .14$. Interference in the DA Words condition was significantly greater than in the DA Stars condition, $p < .001$. Interference in the DA Emojis condition was non-significantly different from that in the

DA Stars condition, $p = .07$. For memory of emojis, the main effect of Condition was non-significant, $F(2, 88) = 0.43$, $MSE = 510.95$, $p = .65$, $\eta_p^2 = .01$.

**Distracting Task Accuracy**

In order to assess the relative level of difficulty of our various distracting tasks, we calculated 1-back accuracy performance for each, as hit rate (number of hits/10) minus false alarm rate (number of false alarms/20). We then conducted a 2 (Attention: baseline or DA; within-subjects) X 3 (Condition: words, stars, or emojis; within-subjects) X 2 (Material: words or emojis; between-subjects) mixed ANOVA[3] (see Table 3). As expected, there was a main effect of Attention, $F(1, 84) = 128.38$, $MSE = 0.01$, $p < .001$, $\eta_p^2 = .60$, such that accuracy on the 1-back tasks was higher during the baseline task phase relative to all DA phases of the experiment.

**Table 3**
*Distracting Task Accuracy During Baseline and Divided Attention (DA) Phases for Each Material Group (Words or Emojis)*

| Material group and task | Words group ($n = 41$) | | Emojis group ($n = 45$) | |
|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* |
| Baseline words | 1.00 | 0.01 | 0.99 | 0.02 |
| DA words | 0.88 | 0.12 | 0.86 | 0.13 |
| Baseline emojis | 0.98 | 0.05 | 1.00 | 0.01 |
| DA emojis | 0.90 | 0.10 | 0.85 | 0.19 |
| Baseline stars | 0.96 | 0.06 | 0.97 | 0.06 |
| DA stars | 0.85 | 0.13 | 0.84 | 0.14 |

The main effect of Condition was also significant, $F(2, 168) = 5.69$, $MSE = .01$, $p < .01$, $\eta_p^2 = .06$. Simple effects contrasts revealed that accuracy in the stars 1-back task was significantly lower overall, compared to the words, $F(1, 84) = 12.24$, $MSE = 0.01$, $p < .001$, $\eta_p^2 =$

[3] While Mauchly's test indicated the assumption of sphericity was violated for the Attention X Condition interaction ($p = .003$), adjusting for degrees of freedom using the Greenhouse-Geisser correction did not affect the significance of the interaction.

.13, and emojis 1-back tasks, $F(1, 84) = 6.52$, $MSE = 0.02$, $p = .01$, $\eta_p^2 = .07$. There was no main effect of Material, $F(1, 84) = 0.53$, $MSE = 0.01$, $p = .47$, $\eta_p^2 = .01$, nor any interactions (*ps* ≥ .13).

**Correlational Analyses**

To determine if there were any accuracy trade-offs between the two concurrent tasks at retrieval, we computed Pearson correlations between the number of words or emojis recalled and distracting task accuracy under DA Words, DA Emojis, and DA Stars conditions. These analyses were conducted separately for each memory material group. There were no significant correlations (*p*s ≥ .10), suggesting that participants were not favoring one task over another.

For the words and emojis groups separately, we also computed correlations between the number of items recalled under DA Words, DA Emojis, and DA Stars conditions in relation to participants' Mill-Hill score, as well as their total score on our emoji use questionnaire. All correlations were non-significant (*p*s ≥ .06).

## Discussion

In the current study, we used the dual-task technique to infer the representational system or processing requirements for words and emojis. Support in the literature has been split in terms of whether emojis are a part of written language or if they are simply ideograms that help to express abstract ideas when using text-based communication may be inefficient. Essentially, we sought to determine if emojis are processed like words, or whether they are processed like images. Free recall of target words was significantly attenuated in the DA Words, but not DA Stars condition, with small though significant declines in the DA Emojis condition, all relative to FA. In line with past studies (Fernandes et al., 2004, 2005, 2006, 2013; Fernandes & Guild, 2009; Fernandes & Moscovitch, 2000, 2002, 2003), these results suggest that memory for words relies primarily on reactivation of verbal representations that is hampered when the distracting task also requires verbal, but not purely visuo-spatial, processing.

With respect to emojis, our hypothesis was that if emojis are processed like images, their retrieval would be hindered by a distracting task that invokes visuo-spatial processing (such as the 1-back task to stars, and to a lesser extent the 1-back task to emojis). As well, a distracting task that invokes verbal processing (such as the 1-back task to words) would have no effect on emoji recall. On the other hand, if emojis are processed like words, memory for emojis would follow the well-documented pattern of interference seen for words. That is, significant disruption from the verbal distracting task (1-back to words) but none from the visuo-spatial task (1-back to stars). Our results suggest emojis are represented using both verbal and visuo-spatial representations: Significant declines were observed on memory for target emojis across all DA conditions relative to FA. These results suggest that reactivation of memory for emoji representations may rely on both visuo-spatial and verbal-based processing mechanisms. Our pattern of data further indicates that emojis in the distracting task engaged sufficient verbal processing to interfere with retrieval of verbal information (recall of words). Our data suggests that emojis could contain at least some verbal-based information (such as a verbal label, perhaps).

Our current results can be best contextualized within the framework of Paivio's dual-coding theory (Paivio, 1991). Here, words are thought to be encoded primarily with a verbal label. Pictures, and possibly emojis, on the other hand, are represented with dual codes: both verbal and imagery (i.e., visuo-spatial). In line with this assertion, our findings showed that recall of emojis was affected only minimally by DA conditions and was similarly attenuated regardless of the material contained in the distracting tasks. Our pattern of results suggests that emojis may be encoded more like pictures, having dual codes. That is, retrieval of emojis could occur via two possible routes, by reactivation of verbal and/or visuo-spatial representations, thus interference effects were smaller overall. As well, memory for emojis was higher overall compared to words. This finding is in line with Paivio's dual-code theory (Paivio, 1991) and parallels the picture superiority effect (Paivio & Csapo, 1973).

What remains unclear, however, is why emoji recall performance was not further hampered under the DA Emojis condition relative to the DA Stars or DA Words conditions. Our assumptions, based in dual coding theory, imply that interference should have been greatest in the DA Emojis condition because both verbal and visuo-spatial codes should have been interfered with, while at least one code is thought to be spared in the DA Word and DA Star conditions. We speculate that perhaps when interference in both visuo-spatial and verbal processing domains occurs, the mind is flexible enough to prioritize one of the representational codes (and sacrifice the other to be attenuated) to ensure at least some form of memory output. For example, when recalling emojis under the DA Stars condition, perhaps participants were able to rely on verbal representational codes of the emojis to maintain retrieval abilities.

In contrast, retrieval of words relied more exclusively on access to verbal representations. When these were simultaneously engaged by the word-based 1-back task, recall of words suffered considerably more than did recall of emojis. We reason that, in the case of words, there is no redundant representation that could be accessed to aid retrieval of target items when competition for processing resources was created in that case (i.e., in the DA Words condition). Interestingly, when recalling words under the DA Emojis condition, performance also suffered. We believe that this is because emojis are automatically afforded verbal labels, and these can interfere with word recall during an emoji-based 1-back task. The labels cannot be selectively ignored in favour of pure visuo-spatial processing of the distracting emojis. Thus, while it is true that words and emojis both contain semantics, if this were the only factor of relevance, the two distracting tasks (words and emojis) should have yielded similar patterns of interference on recall of words, but they did not.

Exploratory analyses found that for both word and emoji recall performance, the general frequency with which one uses emojis in their daily lives did not correlate with the number of items recalled under any retrieval condition. These results suggest that experience with emojis does not bias individuals towards a more verbal representation. Mill-Hill language proficiency scores were similarly not associated with word recall, indicating that English language competency, as measured by the Mill-Hill at least, has no bearing on the extent to which a verbal distracting task can interfere with memory.

One limitation of the current study was that participants in the emoji group had to create verbal labels for the emojis to recall them aloud, which could have biased participants toward forming or relying on an existing verbal memory trace during recall of emojis. However, because we observed different interference patterns for recall of emojis as compared to words, this only underscores that emojis likely engage visuo-spatial processing as well during retrieval. Emoji recall—but not word recall—was significantly impacted by a purely visuo-spatial distracting task (DA Stars). This would not be the case if emojis were simply being ‘converted’ to their underlying verbal labels before being retrieved from memory. It seems plausible that participants were able to imagine the visual representation of each recalled emoji before assigning verbal labels for them at retrieval. It does remain possible, however, that the act of recalling emojis aloud is responsible for their apparent engagement of verbal processing resources and their susceptibility to interference from a word-based distracting task (DA Words), rather than any dual-coding in the study phase. However, support for the idea that emojis are processed with dual codes is also seen in that recall of words was hampered by an emoji-based secondary task (DA Emojis), even when the distracting task decision did not require a verbal response.

An additional limitation of the current work is that words and emojis were presented during study using different modalities (auditorily and visually, respectively). Auditory compared to visual presentation has been shown to enhance recency effect (e.g., Madigan, 1971). This could arguably account for the elevated interference observed for target words during the DA Words retrieval condition, as there would be more items available to be interfered with by the distracting task. However, if elevated recency effects for auditory information could account for our results, memory for words (auditory presentation) should have been higher overall, compared to memory for emojis (visual presentation). This was not the case: memory for emojis was higher than memory for words. Thus, modality of presentation is unlikely to have had a huge impact on our pattern of results. Additionally, some research suggests that when individuals complete a filler task between encoding and retrieval (e.g., a 30-second math task), auditorily presented words do not exhibit larger recency effects than do visually presented words (Duis et al., 1994). As such, we would not even expect a different pattern of results had word presentation been visual as opposed to auditory.

Here we have built upon the well-established dual-task literature and further extended work investigating the cognitive nature of emoji processing. With much of the literature focused on emoji processing in sentence contexts, we are the first to examine emoji processing as it relates to their independent underlying representations. Our findings are consistent with emerging research noting differences in the cognitive processing of emojis compared to both English (Cohn et al., 2018; Gustafsson, 2017; Kaye et al., 2021), as well as Chinese words (Tang et al., 2020, 2021). However, it is important to consider that the context in which emojis are placed, as well as the specific cognitive activities examined, may influence how emojis are processed as compared to words. As such, our results do not necessarily negate work that shows similarities between cognitive processing of words and emojis, especially during higher-order linguistic processing (Barach et al., 2021; Weissman, 2019; Weissman & Tanner, 2018). Overall, our results suggest that emojis, when presented in isolation, are processed differently than written language in terms of their underlying representational code in memory.

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## Declaration of Interest

The authors report no potential competing interests.

## Data Availability Statement

Our pre-registration for this study, along with all materials, experiment files, data, and statistical code can be found on the Open Science Framework (OSF; https://tinyurl.com/yw3u2cau).

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