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Valence generalization across non-recurring structures

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Abstract

Semantically meaningless strings that are associated with affective attributes (US) can become emotionally valenced CS. Jurchiș et al (2020) recently demonstrated CS-US associations may influence evaluations towards previously-unseen letter strings if the latter share grammar construction rules with CS. We replicated those authors' findings in a modified extension (Experiment 1; N_1 = 108), where happy/angry faces (US) were differentially associated with letter strings (CS) constructed using familiar (English) or non-familiar (Phoenician) alphabets. CS-US sequences were sandwiched by evaluations of strings that never appeared as CS, but shared grammar construction rules. However, post-hoc tests indicated valence effects were restricted to participants classified as 'high awareness' or those who had been exposed to longer stimulus durations, suggesting resource-intense deliberations were central during evaluations. Qualitative awareness checks additionally showcased many participants had attributed valences to recurring elements across conditioned and evaluated exemplars. These limitations were collectively addressed in Experiment 2 (N_2 = 140), where participants viewed Phoenician (/English) CS during conditioning but viewed English (/Phoenician) strings during evaluations, meaning no strings nor elements recurred between phases. We found credible valence effects across English and Phoenician strings, with the latter observed across all awareness categories. Because participants were unable to consciously specify any evaluative strategies while evaluating Phoenician strings, we speculate grammar construction rules (organizing relations) may have been non-consciously acquired during conditioning.

Keywords: learning theory, symbolic conditioning, direct realism, valence transfer

Valence generalization across non-recurring structures

Unfamiliar symbols (CS) may elicit evaluative responses following associations with emotionally meaningful symbols (US), in may be described as US-to-CS valence transfer/generalization (Mowrer, 1960). For example, if a pair of unfamiliar and relatively neutral symbols (call these CS1 and CS2) are respectively associated with positively and negatively valenced US then, according to learning theory, CS1 should be positively evaluated relative to CS2, all else remaining equal (Staats & Staats, 1958). While the phenomenon of valence generalization following CS-US associations has been investigated for some time (e.g., Staats, 1996; Mowrer, 1980), it remains to be seen whether the representational processes underlying transfer can be explained using deliberative/propositional processes exclusively, or whether unqualified associations may be involved during acquisition and/or expression (e.g., Gawronski & Bodenhausen, 2006; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010; Corneille & Martens, 2020).

According to the latter perspective, 'simpler' associative architectures constitute (McLaren, McAndrew, Angerer, McLaren, et al., 2019) and/or interact with (Gawronski & Bodenhausen, 2006) propositional processes to produce symbolic evaluations following CS-US pairings. Associations are *simpler* in the sense that they involve unspecified links across unqualified terms that incrementally emerge following symbolic co-occurrences – they are uncontrollably expressed, and may supersede relational/verbal information with minimal deliberative influence (Mandelbaum, 2015; McConell & Rydell, 2014). Because associative theory posits terms can be linked without being (consciously) qualified, valences may be theoretically encoded and applied without necessarily involving resource-intense deliberations (Gawronski & Bodenhausen, 2011). Other theorists have questioned whether 'mental associations' are conceptually useful in the analysis of transfer, claiming constructive propositions can account for most/all evaluative effects following CS-US co-occurrences (cf., Mitchell, De Houwer, & Lovibond, 2009). Transfer is proposed to follow contextually specified deliberations (e.g., *CS co-occurs* *with US, CS predicts US, CS is the same as US*, etc. – De Houwer, 2018), implying (conscious) relation specification as a necessary operating condition for producing transfer (De Houwer, Dessel, & Moran, 2020).

We derived predictions from both perspectives across our first experiment, which expands on a recent procedure described by Jurchiș, Costea, Dienes, Miclea, and Opre (2020). The novelty of the latter report was the demonstration of CS-US transfer effects across letter strings that had never appeared as CS, but were grammatically related to the latter. We outline those authors' experiment below, then highlight some key limitations of their design which our study aimed to address.

In the study by Jurchiș and colleagues, Romanian undergraduates underwent a simultaneous CS-US conditioning protocol where positively or negatively valenced images (US) selectively appeared with English letter strings (CS) from one of two artificial grammar categories (call these Grammar-A and Grammar-B). By 'artificial grammars', we imply letter strings which were constructed following pre-determined rules regarding how various alphabets/elements may be organized within categories. For example, the same bigram *XM* could probabilistically precede the letters *X* or *V* respectively, depending on whether the string was a member of Grammar-A or Grammar-B (Jurchiș et al, p. 1804). So, even as letter strings were semantically meaningless as composites, exemplars within categories shared underlying syntactic rules (also see Norman, Scott, Price, & Dienes, 2019; Rieber, 1967). After CS-US sequences, participants evaluated strings that never appeared as CS previously but were grammatically related to the latter. For ease of illustration, suppose grammars A and B were exclusively associated with positive and negative US respectively. In this case, an expected conditioning effect would be [A – B > 0], which those authors found moderate evidence for (.17 < *d*'s < .53). Because conditioning effects appeared across exemplars never experienced before, but which were otherwise from the same grammar categories as CS, Jurchiș et al reasoned that valences established through CS-US pairings may have generalized across "non-conscious (associative) knowledge structures” (p. 1809).

There are three issues with this claim. First, strings constructed by Jurchiș constituted of characters from a well-known alphabet, which may come with previous affective histories (cf., Head, Neumann, Helton, & Shears, 2013). In this case, participants could attribute valences based on familiar CS elements without ever acquiring any grammar structure knowledge, which those authors did not check for (Jurchiș et al, p. 1807). Second, those authors' conditioning sequences afforded extensive deliberation opportunities – each CS-US pair appeared for over 7 seconds and CS were repeated during blocks. Repeating CS could have occasioned predictive (e.g., *I think these letters always appear with pleasant images*) and confirmatory (e.g., *those letters do appear with pleasant images*) inferences within the same conditioning block, which could have produced the reported conditioning effects without acquisition of any grammar rules (again). Since Jurchiș' awareness checks did not inquire about specific strategies used, nor the extent to which participants felt confident in their subjective strategy, it is unknown whether their awareness metric corresponded with actual grammar structure knowledge or a lack thereof.

A third concern was that Jurchiș et al's claims were based on post-conditioning evaluations only, meaning there was no control for any constitutive valences of artificial grammar categories pre-conditioning, which may not have been affectively 'neutral' across the board (Silva, 2018). When Jurchiș split evaluation performances across groups based on awareness checks for instance, participants from 'less aware' conditions appeared to evaluate positively conditioned grammars more negatively relative to null estimates, whereas only 'more aware' participants produced the predicted within-category trends (p. 1806). This implies CS categories may have already been salient for some participants, which may have mitigated transfer (cf., Cacioppo, Marshall-Goodell, Tassinary, & Petty, 1992). Relatedly, as only participants from higher awareness categories produced predicted within-category trends, resource-intense deliberations may have been central to the effects reported. These issues collectively limit claims of valence generalization across 'associative knowledge structures' as the reported effects may just as readily be explained by assuming deliberative and/or familiarity-based inferences only. Our first experiment attempted to correct for the above limitations to determine whether valence generalization is more (less) likely to reflect associative/resource-minimal or deliberative/resource-intense processes.

Experiment 1

Our first study attempted to replicate Jurchiș et al's conditioning effect while correcting for the limitations noted previously. The experimental phase sequence is illustrated in Figure 1. All participants were initially exposed to Likert evaluation and 2-alternative forced choice (2AFC) tasks to respectively record baseline evaluations and preferences of English and Phoenician letter strings from two grammar categories each (Figure 1, Panels A and B). English strings were adopted from Jurchiș et al (2020). These were transformed into a Phoenician script, a relatively unknown alphabet to contemporary speakers (Rollston, 2020). Participants next underwent a modified CS-US conditioning task, where English and Phoenician strings were differentially associated with happy or angry faces (Panel C). Immediately after conditioning, participants completed a free-selection memory check where they indicated strings they remembered seeing during the preceding conditioning task (Panel D). Next, participants completed a second round of evaluation and preference checks. Strings presented during conditioning and evaluation phases never overlapped, sharing only grammar construction rules. Near the end of the task, participants completed awareness and confidence checks to respectively indicate if a specific evaluative strategy had been derived, subjectively felt confidence in the accuracy of said strategy, as well as any particular evaluative strategy used (Panel E). Awareness check responses were used to classify participants under *high-*, *partial-* and *low-awareness* sub-groups during analyses (see Procedure). To manipulate processing opportunity, CS and US onset asynchronies (SOAs) were varied between participants at 100, 200 and 400 ms. We reasoned if valence generalization relies on resource-intensive deliberations, increased SOAs and/or higher strategy awareness would predict increased valence generalization.

[FIGURE 1 HERE PLEASE]

Method

Participants

152 psychology undergraduate students from the University of the South Pacific (Laucala Campus) took part in exchange for bonus course credit. A fixed-duration sampling strategy was followed for the months of October and November of 2020 before the summer break. The data of 6 participants were excluded for failing attention checks; 38 participants were excluded for slow internet speeds (<8 Mbps), which produced SOA timing errors by +/- 200 ms. The remaining 108 participants were randomly assigned to 100 ms (n = 36; 27.1 ± 7.8 years; 32 females), 200 ms (n = 36; 26.6 ± 7.4 years; 26 females) and 400 ms (n = 36; 24.8 ± 7.3 years; 28 females) SOA conditions. A sensitivity analysis for two-sided repeated t-tests with alpha error set to .05 suggested our sample could reliably detect small-to-moderate effects (d_z = .24) with 70% power. All procedures reported were approved by the local IRB-equivalent and correspond with the Declaration of Helsinki. Participants completed all tasks within 30 minutes on average.

Materials

All tasks were designed and implemented on the Gorilla platform (Amyl-Irvine, Massonnié, Flitton, Kirkham, et al., 2020) and have been made available as open materials (https://gorilla.sc/openmaterials/120282/). All participants completed demographic and personality surveys at the beginning of the experiment. The former assessed age, income, education level, ethnic identity, and religiosity; the latter was a brief measure of the Big Five personality dimensions (Rammstedt & John, 2007). These were not related to the present study and are not discussed further. Strings from four categories of English and Phoenician strings were employed during conditioning and evaluation phases. Two English string categories (*Eng-A*, *Eng-B*) were acquired from Jurchiș' open materials. English characters were transformed into an Early Phoenician script (*Pho-A*, *Pho-B*) using a freeware font package (https://www.wfonts.com/font/early-phoenician/). Each set contained 52 strings, from which 40 appeared as CS and 12 appeared during evaluation phases (see Table 1 for examples of strings used). Conditioning and evaluation phases never presented the same strings. CS assignment to positive and negative US was counter-balanced between participants and alphabets (ie half our sample associated grammars A and B with positive and negative US respectively, and remaining participants associated grammars B and A with positive and negative US respectively). US consisted of 20 Black and 20 White male faces matched, along attractiveness, with happy (positive) and angry (negative) expressions from the Chicago Face Database

(CFD - Ma, Correll, & Wittenbrink, 2015). Positive and negative US varied along normative happiness (99% confidence interval: 1.6 to 2.1) and anger (99% CI: -1.5 to -.7) ratings in positively and negatively valenced directions respectively. Additional face ratings are available in the online materials. All analyses were run on *RStudio* (Team R., 2015) using the *tidyverse* (Wickham, Averick, Bryan, Chang, et al., 2019), *BayesianFirstAid* (Bååth, 2014) ,*effectsize* (Ben-Shachar, Makowski & Lüdecke, 2020), *rstatix* (Kassambara, 2020), *car* (Fox & Weisberg, 2019) and *ggplot2* (Wickham, 2016) packages for analyses and plots respectively. All data, analysis scripts, and supplementary files are available in the Open Science Framework repository (https://osf.io/qdhmy/).

[TABLE 1 HERE PLEASE]

Procedure

Following consent and survey completion, all participants underwent baseline evaluation and preference checks. The former required participants to rate along 10-point scales 'how much they liked' the displayed word on screen. After 16 evaluation trials (four exemplars per grammar category), participants viewed 16 string-pairs sequentially. Across each pair, participants were asked to select which 'word they preferred more', and to provide 'their best guess' when not sure how to respond. All evaluations and 2AFC trials were restricted to 10 second durations, after which the message 'Timeout' would be displayed before appearance of the subsequent trial if no response was detected. Participants next underwent an 80 trial conditioning task. Across any given trial, participants had to click using the mouse pointer on a fixation point that appeared on the left/right sides of the screen. Doing so initiated a display sequence that contained either 20 happy (positive) or 20 angry (negative) faces. Randomly interleaved within the sequence would be two English or two Phoenician strings (English and Phoenician never appeared in the *same* sequence). All sequences additionally included a red/blue dot or a triangle/square figure at random points that appeared for 500 ms. At the end of each sequence, participants had to identify dot color/figure shape from earlier. Failing this attention check three times consecutively dropped the participant from the study. Presentation times for individual CS and US were varied between 100, 200 and 400 ms across three groups.

After conditioning, participants completed a second round of evaluation and preference tests, followed by a 5 trial memory recall task. Across each trial, participants viewed 8 letter strings of which 4 had appeared as CS during conditioning. Remaining strings were constructed using matching alphabets, but followed construction rules from unused grammar categories. Participants could freely select any number of items they recollected from the earlier conditioning phase, with the only response-associated outcome involving the removal of selected options from screen. Each trial progressed automatically after 10 seconds, regardless of whether any selections were made. Finally, participants completed an awareness check containing three items: first, participants selected from four options (Yes/Not sure/I think so/No) following the question 'Did you use a specific strategy for evaluating the words you saw earlier?'. Participants were split into *low*- (No), *partial*- (Not sure/I think so), and *high-awareness* (Yes) sub-groups based on their response. Participants next responded to 'How confident are you that your strategy was 'correct'?' on 5-point scale (scored from *1- Not at all* to *5 – Very confident*). Finally, participants had to option to describe their strategies using written statements. Participant statements from each awareness condition are provided in Supplementary Table A.

Results

1. Valence generalization: Evaluations

All evaluations were collected on 10-point scales before and after conditioning, with lower (higher) ratings corresponding with negative (positive) valence respectively. Valences collected before (T1) and after (T2) conditioning for CS paired with negative and positive US across SOA conditions are illustrated in Figure 3. To control for pre-conditioning differences in category evaluations, all valences were normalized following (T2-T1/T2+T1).

[FIGURE 2 HERE PLEASE]

We first ran three linear models across US valence category (Positive, Negative), string alphabet (English, Phoenician) and awareness levels (high, partial, low) respectively to explain variances across normalized evaluation scores. We found reliable evidence for a difference by US valence – specifically, grammars associated with happy faces were evaluated significantly ($p < .0001$) more positively relative to grammars associated with angry faces, $d = .25$, 95% CI: .19 to .38. We found no reliable differences between alphabets nor awareness levels across valence distributions (all d's $< .03$). We next ran two-sided tests across valence for all combinations of SOAs, alphabet and awareness levels using Welch's tests and Kruschke's *BEST* (*Bayesian estimation supersedes the t-test* -Kruschke, 2013). The latter involves stochastically up-sampling parameter distributions based on observed value ranges using Monte Carlo markov chain (MCMC) simulations. We used 10000 MCMCs for each *BEST*, which is typically sufficient for stable convergence towards normally distributed parameter estimates (Kruschke, 2014). *BEST*s are robust to normality violations, sampling intentions, and heavy kurtosis –no additional corrections are required for multiple comparisons as there are no p-values to estimate. Each MCMC-estimated mean difference is reported alongside their highest probability density intervals (HDIs), which describe normally distributed estimates of likely positive effects. All effect size estimates and 95% HDIs summarized in Figure 3. Finally, Kruschke's *BEST* provides likelihoods that can be continuously interpreted in favor of (or against) predictions made (Kruschke & Liddell, 2018), which can be more informative than binary claims of (non)significance (cf., Amd & Passarelli, 2020). We also report *p*-estimates from frequentist contrasts using Welch's corrections (see Table 2). We found extremely likely ($L > 90\%$) differences in predicted directions (ie Positive – Negative > 0) across *high-awareness* participants exposed to 100 ms and 200 ms SOAs, and across *low-* and *partial-awareness* participants exposed to 400 ms SOAs. Effect distributions were practically equivalent across English and Phoenician strings.

[FIGURE 3 HERE PLEASE]

2. Valence generalization: 2AFC preferences

All 2AFC performances involved selecting between two grammar categories of matching elements (*English-A* vs *English-B* or *Phoenician-A* vs *Phoenician-B* – recall Table 1). 2AFC selections of categories (to-be) positively conditioned were scored as 1's (hits) before and after conditioning (other responses were scored as 0's). Pre-conditioning mean hit counts were entered as priors across Bayesian proportion tests. If posterior mean hits were greater (less) than prior mean estimates, we could claim positively conditioned categories were more likely to be selected after conditioning. All posterior-prior mean proportion differences, 95% HDIs and likelihood estimates for Experiment 1 are summarized in the top panel of Table 3. Preference effects were more likely across English (5/9) relative to Phoenician (3/9) alphabets. Preference effects were more frequently observed across *high-awareness* (4/6) participants relative to their *partial-* (2/6) and *low-awareness* (2/6) counterparts. Across SOAs, proportions were practically equivalent following exposures to 100 ms (3/6), 200 ms (2/6) and 400 ms (3/6) durations.

3. Memory check

After conditioning, participants viewed 40 strings across 5 timed trials, of which 20 strings had appeared previously as CS. Remaining strings were matched along elements but from unused grammar categories (distractors). Participants were asked to select strings they recalled from the previous task. Correct and incorrect recall responses, scored as hits and misses respectively, are summarized in Table 4. Between alphabets, a Bayesian proportion test revealed English strings were more likely ($L = 91\%$) to be misidentified as former CS relative to Phoenician strings.

4. Confidence in evaluative strategy

All participants indicated their subjective level of confidence in their consciously specified evaluative strategy. Confidence in evaluation strategy was collected in part to indirectly measure contingency awareness (cf., Bar-Anan, De Houwer, & Nosek, 2010). A mixed two-way ANOVA with awareness level and SOAs as between-Ss factors did not interact to explain confidence ratings ($p = .971$), with only a main effect of awareness suggesting higher awareness participants were more confident, F (2, 99) = 5.589, $p = .005$. Levene's test was not violated any factor (all p's > .05). Tukey's post-hoc tests confirmed *high-awareness* participants were statistically more confident relative to their *low-* (d = -1.12, 95% CI: -1.91 to -.31, p = .004) and *partial-awareness* (d = -.83, 95% CI: -1.58 to -.07, p = .028) counterparts.

[TABLE 2 HERE PLEASE]

[TABLE 3 HERE PLEASE]

[TABLE 4 HERE PLEASE]

Discussion

108 Fijian undergraduates differentially associated English and Phoenician letter strings (CS) with happy and angry faces (US). CS-US trials were sandwiched between evaluations of strings that never appeared as CS but otherwise followed similar construction rules. Strings from positively conditioned grammars became positively evaluated relative to strings from negatively conditioned grammars, replicating Jurchiș et al's (2020) main effect. However, post-hoc tests indicated valence effects were largely restricted to *high-awareness* participants or those exposed to 400 ms SOAs. Contrary to expectations, we found no valence differences along alphabet exclusively. Yet, memory checks revealed English distractors were more likely to be misidentified as CS relative to Phoenician distractors, implying English and Phoenician grammars may have been acquired at different rates, and/or English string categories were more difficult to discriminate relative to Phoenician categories. Inspection of evaluative strategy checks (Table A) suggested some participants had produced evaluations based on pre-existing histories with elements. Other participants indicated attributing valences to elements that recurred between conditioning and evaluation phases. So, even while the latter phases never produced the same strings, valences may still have been attributed to recurring *elements*, which could have produced the predicted conditioning effects without requiring acquisition of grammar construction rules.

A third confound can be noted if one assumes that grammar construction rules, viz. relations which organize across elements of a term, may be acquired without 'representing' neither the term nor its' elements (Spaulding, 1912). If organizing relations can be acquired and applied without terms[1], valences established for English and Phoenician strings may have overlapped based on matching grammars. For example, if Phoenician and English strings from (say) Grammar-A had respectively appeared with happy and angry

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[1] To see how organizing relations can be acquired 'without' terms, consider how the proposition [*all swans are white*] requires the application of an antecedent [*all*__ *are* ___] relation organizing the contextually situated terms *swans* and *white* (which are themselves propositionally constituted – cf., Thompson, 2019). By assuming organizing relations can ontologically subsist without terms, the former can be redundantly applied across a practically infinite number of contexts without requiring indirect representation (Spaulding, 1912). The operation of 'term-less' (non-conscious) organizing relations may be phenomenally situated within Holtian 'cross sections', otherwise neorealism's "most fundamental concept" (Tonneau, 2011, p. 5). We elaborate on the concept of 'cross sections' in the General Discussion.

faces in the same conditioning block, exemplars of either category may have been evaluated less positively (negatively) than had both alphabets appeared with happy (angry) faces exclusively. This speculation generates an additional novel prediction – if (valenced) organizing relations are acquired without terms, than valences should generalize across matching/accommodating grammatical structures even if there are *no* common elements. We tested this claim in a second experiment, where CS and evaluated strings were held constitutively distinct (ie constructed with different alphabets) but shared parallel organizing relations (construction rules). Note that this design featured ensured no strings nor elements recurred between conditioning and evaluation phases.

Experiment 2

Our earlier task sequence was modified in two ways. First, strings presented during evaluation and conditioning phases varied by alphabet. Half of all participants (in the *Eng-Eval* group) evaluated English strings after viewing Phoenician CS-US sequences. Remaining participants (in the *Pho-Eval* group) evaluated Phoenician strings after viewing English CS. Second, we repeated CS at least once during conditioning trials to facilitate acquisition. Note that because conditioned and evaluated exemplars were constructed from different alphabets, there were no common elements between phases.

Method

Participants

160 young adults from the United States were recruited from the academic site www.prolific.co. 7 participants were excluded for failing attention checks, and 13 participants were excluded for variable internet connection speeds, leaving a final sample of 140 young adults. These were randomly assigned to *Eng-Eval* (n = 70; 24.2 ± 4.5 years, 26 females) and *Pho-Eval* (n = 70; 24.1 ± 4.4 years, 29 females) groups. Participants were compensated at a rate of 8.50 USD per hour. All experimental procedures were completed within 30-40 minutes.

Materials

All materials from Experiment 1 were re-used.

Procedure

Similar to earlier phase sequences, all participants completed an 80 trial conditioning task sandwiched by evaluation and preference phases. After conditioning, participants completed memory and awareness checks. Across *Eng-Eval* participants, English strings appeared as CS and Phoenician strings appeared during evaluations. Assignment was reversed across *Pho-Eval* participants, who viewed Phoenician strings as CS and English strings appeared during evaluations. Grammar category designations to happy and angry faces were counter-balanced across groups. All SOAs were held constant at 200 ms. All participants completed memory and awareness checks as before. Across the former, participants only viewed CS and distractors from alphabets they had viewed during conditioning. For example, *Eng-Eval* participants viewed Phoenician CS during conditioning, followed by Phoenician CS and Phoenician distractors during memory checks.

Results

1. Valence generalization: Evaluations

We replicated all analysis steps reported earlier. First, we ran three linear models across US valence category (Positive, Negative), string alphabet (English, Phoenician) and awareness levels (high, partial, low) to explain variances across normalized evaluation scores. Similar to our first experiment, we found the predicted effect between valence categories, $d = .13$, 95% CI: .09 to .17, and no reliable differences between awareness levels, $d = .06$, 95% CI: .01 to .10. Different to our initial findings, we found English strings were more negatively evaluated relative to Phoenician strings overall, $d = -.20$, 95% CI: -.24 to -.16. A series of post-hoc Welch's tests and *BEST*s across all awareness and alphabet combinations provided statistical (all p's < .038) and credible (all L's > 95%) evidence for valence effects across most categories – only participants classified as *high-awareness* did not produce the predicted effect following English string evaluations (Table 2, bottom panel).

2. Valence generalization: 2AFC preferences

All posterior-prior mean hit differences across Experiment 2, alongside 95% credibility intervals and likelihood estimates, are summarized in the bottom panel of Table 3. Other than *low-awareness* participants who had viewed English CS, all remaining awareness and alphabet combinations indicated increased proportions of posterior hit frequencies relative to priors (all L's > 99%).

3. Memory check

Correct and inaccurate memory check responses across Experiment 2 are summarized in the bottom panel of Table 4. Between alphabets, a Bayesian proportion test revealed English strings were extremely likely (L > 99%) to be misidentified as former CS relative to Phoenician strings.

4. Confidence in evaluative strategy

A mixed two-way ANOVA with awareness level and alphabet as between-subjects factors did not reveal any interaction terms ($p = .697$) or a main effect for alphabet ($p = .817$). Only a main effect of awareness was found, $F(2, 134) = 16.448$, $p < .0001$. Levene's test indicated all factor interactions were homoscedastic (all p's > .05). Tukey's post-hoc tests confirmed *high-awareness* participants were more confident relative to their *low-* ($d = -1.62$, 95% CI: -2.29 to -.96, $p < .0001$) and *partial-awareness* ($d = -.69$, 95% CI: -1.31 to -.07, $p = .025$) counterparts.

Discussion

140 American adults underwent CS-US conditioning sandwiched by evaluation phases. Across phases, CS and evaluated strings were matched along grammar construction rules but varied along elements. Half our sample viewed Phoenician strings as CS and English strings during evaluations (*Eng-*

Eval), with remaining participants viewing English strings as CS and Phoenician strings during evaluations (*Pho-Eval*). Both groups produced credible valence effects - categories associated with happy faces were more likely to be positively evaluated relative to categories associated with negative faces across most alphabet and awareness level combinations. Inspection of qualitative strategy descriptions revealed *Eng-Eval* participants produced evaluations based on elemental attributes (e.g., based on "observations of X" – see Table A), whereas *Pho-Eval* participants appeared less likely to specify any consistent evaluative strategies. Since the latter group produced predicted valence effects across awareness levels *and* could not consciously specify any consistent evaluative strategies, we propose that, at least across *Pho-Eval* participants, element-element organizing relations (construction rules) may have been acquired without terms and subsequently applied to novel (but relationally consistent) structures. Because organizing relations require no terms to be mentally linked nor any relations to be consciously specified, they would necessarily be non-associative and non-conscious (Spaulding, 1912).

General Discussion

We report two modified replications of a study by Jurchiș and colleagues (2020), who claimed to have demonstrated valence generalization across non-conscious and associative knowledge structures. Our first study replicated Jurchiș et al's main effect, where strings grammatically associated with CS paired with happy (angry) faces were evaluated positively (negatively) relative to each other after conditioning. Bayesian post-hoc tests revealed valence effects were more likely across higher SOAs and/or higher strategy awareness, implying deliberative processes had been central to the effects observed. Inspection of evaluative strategy descriptions additionally revealed many participants may have attributed valences to recurring elements between conditioned and evaluated strings, and/or produced evaluations based on element knowledge (ie without conscious knowledge of grammar rules - Table A). We corrected for element recurrence across Experiment 2, where participants viewed English (or Phoenician) CS during conditioning, but evaluated Phoenician (English) strings. That is, CS and evaluated strings were constructed using alternate alphabets but shared grammar rules (recall Table 1). We found credible valence generalization across the elementally distinct structures that were matched along construction rules viz. how elements within particular grammar structures are organized relative to each other. These findings expand on our earlier experiment and the investigation reported by Jurchiș et al (2020), as both of those investigations had repeated *elements* across conditioned and tested structures.

We also found conditioned relations may be interfered with during expression if there are previous relations operating on the evaluations target - participants who had to deliberately evaluate English strings reported doing so based on previously salient histories associated with familiar elements. To compare, Phoenician elements were unfamiliar and less likely to be embodied across previous histories –

consequently, participants did not specify any consistent evaluative strategies. Yet, this same group produced valence effects across all awareness levels, devaluing any central role of deliberative processes.

We had proposed how the latter effects may be predicted by assuming that 'organizing relations' may be acquired without terms. Relations that organize across perceptual regularities, such as how elements are sequenced across letter strings, are likely to be operative without terms in order to be contextually redundant. This describes how the relation [*all* __ *are* __] can organize across an infinite number of compatible symbolic terms [e.g., *all swans are white, all leaves are green, all pigs are fat*] without requiring a unique (fragmented) representation[2] of each proposition. To achieve redundancy without representation, organizing relations must necessarily be 'simpler' and ontologically prior to their contextually specified applications (e.g., *all* __ *are* __ is simpler than *all swans are white*). Instead of being represented, organizing relations are proposed to be embodied across spatiotemporally extended 'cross sections' following a direct realist epistemology (Holt, 1914). Briefly, a cross section implies 'that' portion of the environment an agent is interacting with at any given duration, where *time* and *space* are extended, non-discrete, and phenomenally integrated (Tonneau, 2013, p. 239; also see McMullen, 2018). Cross sections initiate with ecological perturbances across an agent's perceptual field that are attended to (Holt, 1915, p. 396; Greeno, 1994; Gibson, 1966). The relational complexity of individual cross sections depend on the tokens afforded by one's context in conjunction with the biological constraints particular to an agent (cf., Timberlake, 1994). Cross sections embody the plurality of all relations operating on the agent, including those which organize across perceived structures, without necessarily entering conscious awareness (Perry, 1912, p. 151). From this framework, the acquisition and expression of organizing relations can be readily explained without involving represented links between terms, whether qualified (propositional) or not (associative). We provide some additional implications of our framework after noting some limitations of the present design.

One procedural concern was that qualitative response completion was voluntary, where participants could freely describe any evaluative strategy used (Figure 1, Panel E). We left the latter response optional to ensure participants did not feel 'forced' to derive some arbitrary strategy post-conditioning, which can skew reports (cf., Hauser, Ellsworth, & Gonzalez, 2018). A consequence of that decision was that over half our sample did not provide any qualitative statements, meaning no definite claims about those participants' subjective strategies can be made. A future work can attempt to enforce qualitative awareness checks post-conditioning to explore the extent to which the present response set correlates with their 'forced' variants.

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[2] We are largely in agreement with Porot and Mandelbaum's (2020) notion of 'fragmented knowledge structures', in that cross-sections, as ultimately relational entities, must be 'mandatorily' acquired (as relations cannot be incremental) and redundantly applied. We deviate from Porot and Mandelbaum's account in that our 'redundancies' are embodied across directly experienced relations rather than their indirect representations (Charles, 2011; Tonneau, 2004). This includes organizing relations sans terms, meaning they are neither associative nor propositional. Since all conscious thoughts require terms that are propositionally defined (cf., Thompson, 2019), organizing relations are likely to be operative outside conscious awareness.

A related concern may be raised regarding the diagnostic value of our post-hoc awareness checks and confidence ratings (Hauser et al., 2018). Higher confidence may have implied greater contingency awareness (Bar-Anan et al., 2010), but this could have also reflected pre-conditioning differences in dispositional confidence, which may have unduly influenced evaluative appraisal and expression (cf., Wolfe & Grosch, 1990). On balance, awareness/confidence ratings across Experiment 2 did not co-vary with conscious strategy specification nor valence transfer when participants evaluated Phoenician strings, meaning dispositional confidence was unlikely to be a moderator across the latter effects. A future replication should still attempt to control for individual dispositional (confidence) differences beforehand to check the generalizability of the reported effects, which we did not do presently.

Another concern may be the small-to-moderate valence effects reported presently ($.15 < d\text{'s} < .25$), at least relative to the effect sizes reported by Jurchiș et al. In response, recall that one of the limitations of those authors' design was reporting along post-conditioning contrasts exclusively, meaning no information was provided regarding any potential pre-conditioning valences of grammar categories. In fact, supplementary analyses indicated English grammar categories across Experiment 2 were differentially evaluated ($d = .25$, 95% CI: .19 to .31) before any conditioning even took place. This suggests direct contrasts along post-conditioning evaluations exclusively may not have reflected conditioned information. We controlled for this here by normalizing across pre- and post-conditioning scores, which led to a reduction across participants classified as having credibly demonstrated transfer. So, while our effects were of moderate power relative to earlier reports, the additional controls implemented here render our conclusions just as credible.

A more general criticism is that we did not compare across any specific evaluative-learning theories, which can incorporate (say) mutually interacting associative-propositional architectures (e.g., Gawronski & Bodenhausen, 2011). However, one of our goals presently was to present a direct realist approach towards evaluative learning. For readers who adopt our framework, distinctions between 'associative-propositional' and/or 'functional-cognitive' processes become largely redundant since (we assume) unifying 'cross-sections' hierarchically embody *all* psychologically relevant relations, regardless of conscious accessibility (cf., Tonneau, 2013). Our position explains how (say) affective relations influence motivational systems in the absence of top-down/symbolic moderation (e.g., Amd & Baillet, 2019; Boag, 2008). Cross sections may also embody organizing relations that operate 'without terms' and therefore without explicit deliberation, as the present work suggests. It is a truism that explicit evaluations require constructive deliberations – learning histories cannot be contextually re-instated without relational specification (De Houwer, 2007; De Houwer et al., 2020; then see Staats & Eifert, 1990). A theory of cross sections elaborates on this view by pointing out that organizing (and affective) relations may inform the subsequent construction of contextually applied propositions. If *relations* operate as minimal informational units without terms, they cannot be specified nor mentally linked. This claim is evolutionarily reasonable, as it explains how relations embodied over the course of an organism's ontogenetic and phylogenetic histories may not necessarily be present to conscious awareness but still be expressed when a supportive context appears (e.g., Maze, 2001; Tonneau, Abreu, & Cabrera, 2004). We demonstrated that our framework can generate novel predictions in the context of symbolic evaluative learning, illustrating the application of a 'direct realist' epistemology to symbolic learning theory.

For readers not interested in our approach, some discrepancies across the present study require explanation. On the one hand, evaluation differences along awareness and SOAs implied deliberative processes were central to the effects observed across Experiment 1. Yet, applying the same criterion to Experiment 2 suggest deliberations were not central to transfer – in fact, 'high awareness' participants who evaluated English strings were the only sub-group who did not produce transfer, directly countering a deliberation-centric explanation. At the same time, our second experiment appears difficult to reconcile with standard associative theory as there were no common (elemental) representations between evaluated and conditioned exemplars that could be theoretically strengthened/weakened (Wills, Edmunds, Le Pelley, et al., 2019). Alternatively, relations without terms [e.g., *all__ are* ___] are not inherently specifiable, and require application to be consciously accessed to (say) determine truth value (De Houwer et al., 2020). Nevertheless, some representationalist learning theory may be creatively iterated to accommodate some/all of the claims raised above, perhaps even challenge them substantially. We welcome such efforts, and believe them to be conducive to the development of symbolic learning theory. In the meantime, readers interested in the framework proposed here are encouraged to consider how organizing and/or affective relations may be exploited to generate novel predictions. For instance, if valences generalize through non-conscious organizing relations, as our current work suggests, future works can attempt to 'isolate' said relations (e.g., by embodying them in contextual cues – cf., Amd & Roche, 2017) to determine if said relations are valenced in the absence of any conditioning histories. A demonstration of constitutive affective properties across organizing relations, or at least their symbolic manifests, would vindicate the framework proposed here.

References

Amd, M., & Passarelli, D. A. (2020). Dissociating preferences from evaluations following subliminal conditioning. *Acta Psychologica*, *204*, 103023. https://doi.org/10.1016/j.actpsy.2020.103023

Amd, M., & Baillet, S. (2019). Neurophysiological Effects Associated With Subliminal Conditioning of Appetite Motivations. *Frontiers in Psychology*, *10*, 457. https://doi.org/10.3389/fpsyg.2019.00457

Amd, M., de Almeida, J. H., de Rose, J. C., Silveira, C. C., & Pompermaier, H. M. (2017). Effects of orientation and differential reinforcement on transitive stimulus control. *Behavioural Processes*, *144*, 58–65. https://doi.org/10.1016/j.beproc.2017.08.014

Amd, M., & Roche, B. (2017). Transforming valences through transitive inference: How are faces emotionally dissonant? *The Quarterly Journal of Experimental Psychology*, *70*(12), 2478–2496. https://doi.org/10.1080/17470218.2016.1246576

Amyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*(1), 388–407. https://doi.org/10.3758/s13428-019-01237-x

Bååth, R. (2014). Bayesian first aid: A package that implements Bayesian alternatives to the classical*. test functions in R. *Proceedings of UseR*, 2014, 2.

Bar-Anan, Y., De Houwer, J., & Nosek, B. A. (2010). Evaluative conditioning and conscious knowledge of contingencies: A correlational investigation with large samples. *Quarterly Journal of Experimental Psychology*, *63*(12), 2313–2335. https://doi.org/10.1080/17470211003802442

Ben-Shachar, Makowski & Lüdecke (2020). Compute and interpret indices of effect size. *CRAN*. Available from https://github.com/easystats/effectsize.

Boag, S. (2008). 'Mind as feeling' or affective relations?: A contribution to the school of Andersonian realism. *Theory & Psychology*, *18*(4), 505–525. https://doi.org/10.1177/0959354308091841

Cacioppo, J. T., Marshall-Goodell, B. S., Tassinary, L. G., & Petty, R. E. (1992). Rudimentary determinants of attitudes: Classical conditioning is more effective when prior knowledge about the attitude stimulus is low than high. *Journal of Experimental Social Psychology, 28*(3), 207–233. https://doi.org/10.1016/0022-1031(92)90053-M

Corneille, O., & Mertens, G. (2020). Behavioral and physiological evidence challenges the automatic acquisition of evaluations. *Current Directions in Psychological Science.* https://doi.org/10.1177/0963721420964111

De Houwer, J., Van Dessel, P., & Moran, T. (2020). *Attitudes beyond associations: On the role of propositional representations in stimulus evaluation*. In *Advances in experimental social psychology* (Vol. 61, pp. 127-183). Academic Press. https://doi.org/10.1016/bs.aesp.2019.09.004

De Houwer, J. (2018). Propositional models of evaluative conditioning. *Social Psychological Bulletin*, *13*(3), 1-21. https://doi.org/10.5964/spb.v13i3.28046

De Houwer, J. (2007). A conceptual and theoretical analysis of evaluative conditioning. *The Spanish Journal of Psychology*, *10*(2), 230–241. https://doi.org/10.1017/S1138741600006491

Fox, J. & Weisberg, S. (2019). *An {R} Companion to Applied Regression, Third Edition*. Thousand Oaks CA: Sage.

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: An integrative review of implicit and explicit attitude change. *Psychological Bulletin, 132*(5), 692–731. https://doi.org/10.1037/0033-2909.132.5.692

Gawronski, B., & Bodenhausen, G. V. (2011). *The associative-propositional evaluation model: Theory, evidence, and open questions*. In J. M. Olson & M. P. Zanna (Eds.), *Advances in experimental social psychology*, Vol. 44 (p. 59–127). Academic Press. https://doi.org/10.1016/B978-0-12-385522-0.00002-0

Gibson, J.J. (1966). *The Senses Considered as Perceptual Systems*. Boston and New York:Houghton Mifflin

Greeno, J. G. (1994). Gibson's affordances. *Psychological Review, 101*(2), 336–342. https://doi.org/10.1037/0033-295X.101.2.336

Hauser, D. J., Ellsworth, P. C., & Gonzalez, R. (2018). Are manipulation checks necessary? *Frontiers in Psychology*, *9*, 998. https://doi.org/10.3389/fpsyg.2018.00998

Head, J., Neumann, E., Helton, W. S., & Shears, C. (2013). Novel word processing. *The American journal of Psychology, 126*(3), 323–333. https://doi.org/10.5406/amerjpsyc.126.3.0323

Hofmann, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin, 136*(3), 390–421. https://doi.org/10.1037/a0018916

Holt, E. B. (1915). Response and cognition II.: Cognition as response. *The Journal of Philosophy*, *Psychology and Scientific Methods, 12*(15), 393-409. https://doi.org/0.2307/2012945

Holt, E. B. (1914). *The concept of consciousness*. New York, NY: Macmillan

Jurchiș, R., Costea, A., Dienes, Z., Miclea, M., & Opre, A. (2020). Evaluative conditioning of artificial grammars: Evidence that subjectively-unconscious structures bias affective evaluations of novel stimuli. *Journal of Experimental Psychology: General*, 149(9), 1800–1809. https://doi.org/10.1037/xge0000734

Kassambara, A. (2020). rstatix: Pipe-Friendly Framework for Basic Statistical Tests. *R package version 0.6.0.* Available from https://CRAN.R-project.org/package=rstatix

Kruschke, J. (2014). *Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan*. Academic Press.

Kruschke, J. K., & Liddell, T. M. (2018). The Bayesian New Statistics: Hypothesis testing, estimation, meta-analysis, and power analysis from a Bayesian perspective. *Psychonomic Bulletin & Review, 25*(1), 178-206

Ma, D. S., Correll, J., & Wittenbrink, B. (2015). The Chicago Face Database: A free stimulus set of faces and norming data. *Behavior Research Methods, 47*(4), 1122–1135.

Mandelbaum, E. (2015). Associationist theories of thought. *Retrieved from* https://plato.stanford.edu/entries/associationist-thought/

Maze, J. R. (2001). Social constructionism, deconstructionism and some requirements of discourse. *Theory & Psychology, 11*(3), 393–417. https://doi.org/10.1177/0959354301113006

McConnell, A. R., & Rydell, R. J. (2014). *The systems of evaluation model: A Dual-systems approach to attitudes*. In J. W. Sherman, B. Gawronski, & Y. Trope (Eds.), *Dual-process theories of the social mind* (p. 204–218). The Guilford Press.

McLaren, I. P. L., McAndrew, A., Angerer, K., McLaren, R., Forrest, C., Bowditch, W., Monsell, S., & Verbruggen, F. (2019). Mackintosh Lecture—: Association and cognition: Two processes, one system. *Quarterly Journal of Experimental Psychology*, *72*(2), 98–117. https://doi.org/10.1177/1747021818766287https://doi.org/10.1177/1747021818766287

McMullen, T. (2018). Memory and its offspring: Realism and the “specious present”. *Theory & Psychology, 28*(2), 172–192. https://doi.org/10.1177/0959354318760741

Mitchell, C. J., De Houwer, J., & Lovibond, P. F. (2009). The propositional nature of human associative learning. *Behavioral and Brain Sciences, 32*(2), 183–198. https://doi.org/10.1017/S0140525X09000855

Mowrer, O. H. (1960). *Learning theory and the symbolic processes*. John Wiley & Sons Inc. https://doi.org/10.1037/10772-000

Mowrer, O. H. (1980/2013). *Psychology of language and learning*. Springer Science & Business Media.

Norman, E., Scott, R. B., Price, M. C., & Dienes, Z. (2016). The relationship between strategic control and conscious structural knowledge in artificial grammar learning. *Consciousness and Cognition, 42*, 229-236. https://doi.org/10.1016/j.concog.2016.03.014

Perry, R. B. (1912). *A realistic theory of independence*. In Holt, E. B., Marvin, W. T., Montague, W. P., Perry, R. B., Pitkin, W. B., & Spaulding, E. G. (1912) *The New realism: coöperative studies in philosophy*. Macmillan.

Porot, N., & Mandelbaum, E. (2020). The science of belief: A progress report. Wiley interdisciplinary reviews. *Cognitive science*, e1539. Advance online publication. https://doi.org/10.1002/wcs.1539

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of research in Personality*, *41*(1), 203-212. https://doi.org/10.1016/j.jrp.2006.02.001

Rollston, C. (2020). The Emergence of Alphabetic Scripts. *A Companion to Ancient Near Eastern Languages*, 65-81. https://doi.org/10.1002/9781119193814.ch4

Silva, F. J. (2018). The puzzling persistence of "neutral" conditioned stimuli. *Behavioural Processes*, *157*, 80–90. https://doi.org/10.1016/j.beproc.2018.07.004

Spaulding, E. G. (1912). *A defense of analysis*. In Holt et al. 1912.

Staats, A. W. (1996). *Psychological behaviorism*. Springer Publishing Co.

Staats, A. W., & Eifert, G. H. (1990). The paradigmatic behaviorism theory of emotions. *Clinical Psychology Review*, *10*(5), 539–566. https://doi.org/10.1016/0272-7358(90)90096-S

Staats, A. W., & Staats, C. K. (1958). Attitudes established by classical conditioning. *The Journal of Abnormal and Social Psychology*, *57*(1), 37–40. https://doi.org/10.1037/h0042782

Team, R. (2015). *RStudio: integrated development for R*. RStudio, Inc., Boston, MA URL http://www. rstudio. com, 42, 14.

Timberlake, W. (1994). Behavior systems, associationism, and Pavlovian conditioning. *Psychonomic Bulletin & Review*, *1*(4), 405–420. https://doi.org/10.3758/BF03210945

Tonneau, F. (2013). Neorealism: Unifying cognition and environment. *Review of General Psychology*, *17*(2), 237-242. https://doi.org/10.1037/a0032939

Tonneau, F. (2011). *Holt's realism: New reasons for behavior analysis*. In E. P. Charles (Ed.), *A new look at New Realism: The psychology and philosophy of E. B. Holt* (pp. 33–55). New Brunswick, NJ: Transaction Publishers

Tonneau, F. (2004). Consciousness outside the head. *Behavior and Philosophy*, *32*, 97–123

Tonneau, F., & González, C. (2004). Function Transfer in Human Operant Experiments: The Role of Stimulus Pairings. *Journal of the Experimental Analysis of Behavior*, *81*(3), 239–255. https://doi.org/10.1901/jeab.2004.81-239

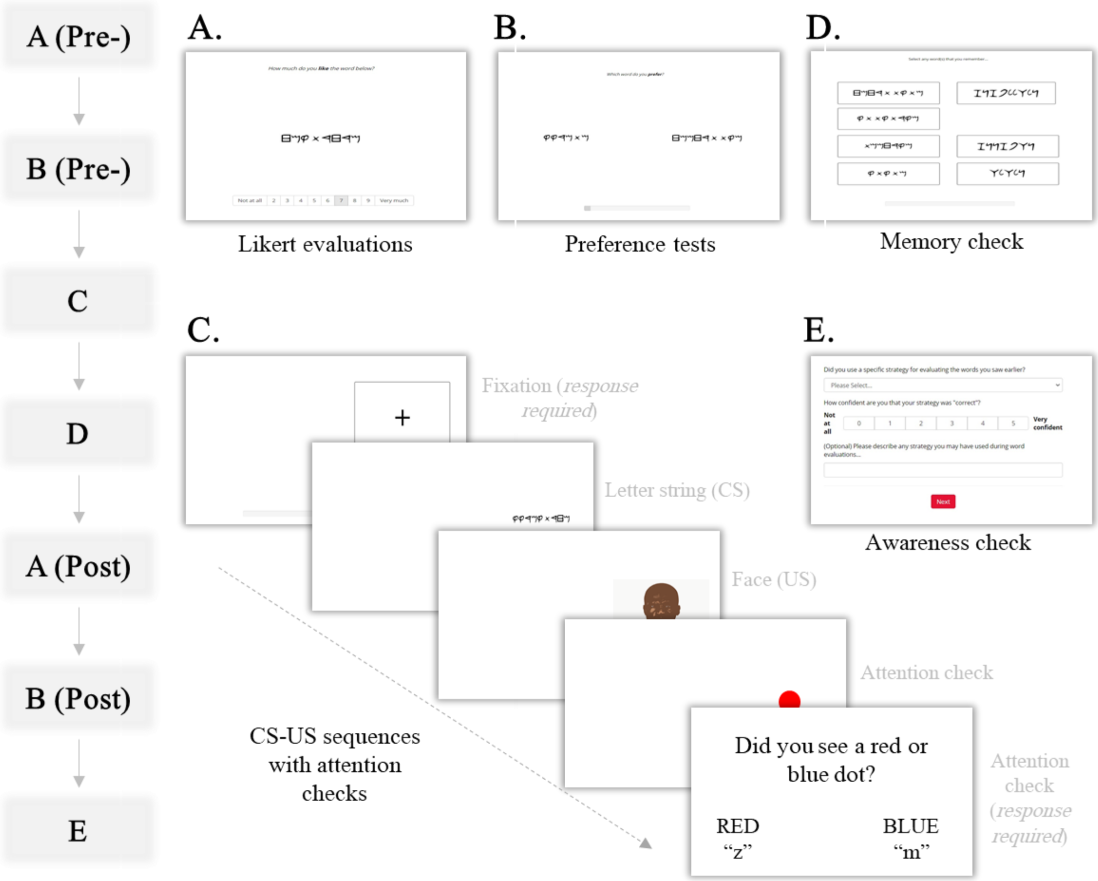
Tonneau, F., Abreu, N. K., & Cabrera, F. (2004). Sitting on the word "chair": Behavioral support, contextual cues, and the literal use of symbols. *Learning and Motivation*, *35*(3), 262–273. https://doi.org/10.1016/j.lmot.2004.03.001

Wickham, H. (2016). ggplot2. Wiley Interdisciplinary Reviews: *Computational Statistics*, *3*(2), 180-185. https://doi.org/10.1002/wics.147

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D. A., François, R., ... & Kuhn, M. (2019). Welcome to the Tidyverse. *Journal of Open Source Software, 4*(43), 1686.

Wills, A. J., Edmunds, C. E., Le Pelley, M. E., Milton, F., Newell, B. R., Dwyer, D. M., & Shanks, D. R. (2019). Dissociable learning processes, associative theory, and testimonial reviews: A comment on Smith and Church (2018). *Psychonomic bulletin & review, 26*(6), 1988-1993. https://doi.org/10.3758/s13423-019-01644-3

Wolfe, R. N., & Grosch, J. W. (1990). Personality correlates of confidence in one's decisions. *Journal of Personality*, *58*(3), 515–534. https://doi.org/10.1111/j.1467-6494.1990.tb00241.x



How much do you **like** the word below?

Which word do you **prefer**?

Select any word(s) that you remember...

Did you use a specific strategy for evaluating the words you saw earlier?

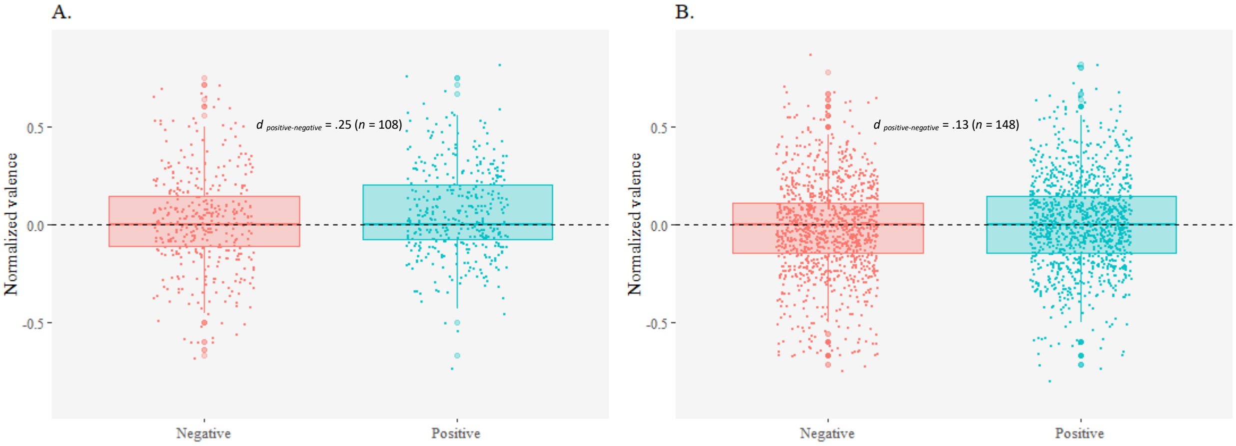
How confident are you that your strategy was "correct"?

(Optional) Please describe any strategy you may have used during word evaluations...

Did you see a red or blue dot?

RED "z" BLUE "m"

*Figure 1***.** Task sequence across both experiments reported presently. All participants evaluated English and/or Phoenician strings before and after conditioning using 10-point Likert scales (Panel A) and 2-alternative forced choice tests (Panel B). Conditioning sequences initiated with a fixation point on the left or right sides of the screen (Panel C). A location-contingent keypress led to a sequence of happy/angry faces (US) interspersed with English or Phoenician strings (CS) and attention checks. Post-conditioning, participants completed CS memory checks (Panel D) and indicated awareness of evaluative strategy (Panel E). Additional details are provided in the Procedure.



d $_{positive\text{-}negative}$ = .25 (*n* = 108)

d $_{positive\text{-}negative}$ = .13 (*n* = 148)

Figure 2. Boxplots of normalized evaluation ratings (*y*-axes) for grammar categories associated with negative and positive US respectively (*x*- axes) across Experiments 1 (Panel A) and 2 (Panel B). Cohen's differences (*d*) and experiment sample sizes (*n*) are provided in callouts.

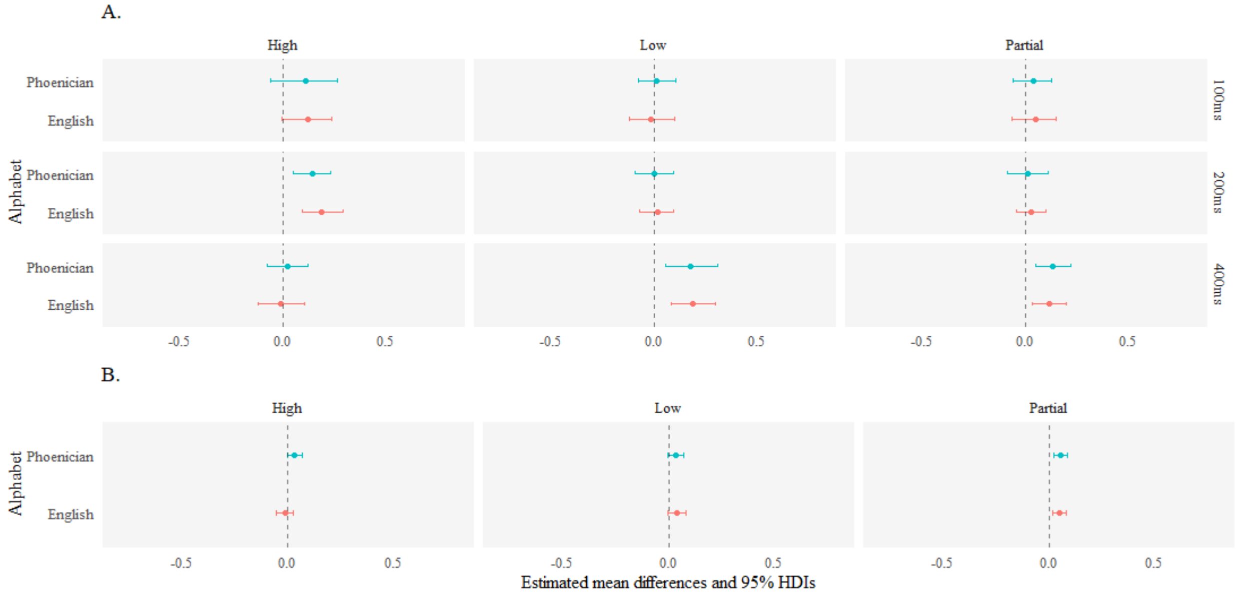


Figure 3. Estimated mean evaluation differences and 95% HDIs across English (red) and Phoenician (blue) strings across Experiments 1 (Panel A) and 2 (Panel B). Columns indicate awareness levels (high-/low-/partial-). Across Experiment 1, row panels indicate SOA durations (100/200/400 ms).

Table 1. *Examples of English and Phoenician strings*

ENGLISH-A	*ENGLISH-B*	*PHOENICIAN-A*	*PHOENICIAN-B*
XMXRTTVTM	XMTRRRM	𐤇𐤇𐤓𐤕𐤒𐤕𐤌	𐤇𐤌𐤒𐤓𐤇𐤓𐤌
VTTVTRVM	VVTRXRM	𐤒𐤒𐤕𐤓𐤒𐤕𐤌	𐤇𐤌𐤒𐤓𐤇𐤓𐤓𐤓𐤌
XMMXRVM	XMTRM	𐤇𐤌𐤇𐤓𐤕𐤒𐤕𐤌	𐤒𐤒𐤕𐤓𐤌𐤕𐤓𐤌
VTVTM	XXRRM	𐤇𐤌𐤌𐤇𐤓𐤒𐤕𐤌	𐤇𐤌𐤒𐤕𐤓𐤌𐤕𐤌
XXRVTM	XMVRMTM	𐤇𐤇𐤓𐤒𐤌	𐤒𐤒𐤓𐤇𐤓𐤓𐤌
VTTTVTM	VVTTRXRRM	𐤇𐤇𐤓𐤒𐤕𐤓𐤒𐤕𐤌	𐤇𐤌𐤕𐤓𐤓𐤌
XXRVTRTVM	XMVRMTRM	𐤇𐤇𐤓𐤕𐤒𐤌	𐤒𐤒𐤕𐤕𐤓𐤇𐤌
VVTRTTVTM	VVTTTRMTM	𐤒𐤕𐤒𐤕𐤓𐤕𐤕𐤒𐤌	𐤒𐤒𐤓𐤌𐤒𐤓𐤌𐤕𐤌
XMXRTTTVM	XMVRMVRXM	𐤇M𐤇𐤓𐤕𐤕𐤒𐤌	𐤇𐤌𐤒𐤕𐤓𐤇𐤓𐤌
XMMXRTVM	VVTTRMTRM	𐤒𐤕𐤕𐤒𐤌	𐤒𐤒𐤕𐤓𐤇𐤌
VTVTRTVTM	VVRMVRXRM	𐤒𐤒𐤕𐤓𐤕𐤕𐤕𐤒𐤌	𐤒𐤒𐤕𐤕𐤓𐤌𐤕𐤌
VTTTVTRVM	VTRRM	𐤇𐤇𐤓𐤕𐤕𐤕𐤒𐤌	𐤇𐤌𐤒𐤕𐤕𐤓𐤇𐤓𐤌
XXRVTRVM	VVTRXRRM	𐤒𐤕𐤒𐤕𐤓𐤒𐤕𐤌	𐤇𐤌𐤒𐤕𐤕𐤕𐤓𐤇𐤌
VTVTRVM	XMVTRMTRM	𐤒𐤕𐤕𐤒𐤕𐤓𐤕𐤒𐤌	𐤒𐤒𐤕𐤕𐤕𐤓𐤇𐤌
XXRTTTVTM	XMVRMTRRM	𐤇𐤌𐤌𐤌𐤇𐤓𐤒𐤌	𐤒𐤒𐤓𐤌𐤕𐤓𐤓𐤌
VTTVTM	VVRXRRRM	𐤒𐤒𐤕𐤓𐤕𐤒𐤕𐤌	𐤇𐤇𐤓𐤓𐤓𐤌
VVTRTTVTM	XMVTRXRRM	𐤒𐤕𐤕𐤕𐤒𐤌	𐤒𐤒𐤕𐤓𐤇𐤓𐤓𐤓𐤌
XMMMXRVTM	VTRRRM	𐤇𐤌𐤇𐤓𐤒𐤌	𐤒𐤒𐤓𐤌𐤕𐤌
XMXRVTM	XMVRXM	𐤇𐤌𐤌𐤇𐤓𐤕𐤕𐤒𐤌	𐤒𐤒𐤓𐤌𐤒𐤓𐤇𐤌
XXRTTVTM	XMVTRXM	𐤇𐤌𐤌𐤌𐤇𐤌	𐤒𐤒𐤓𐤇𐤌

Out of 52 exemplars per grammar category (A, B), 40 were used during conditioning and 12 were used during evaluation and preference tests. The former appeared once during conditioning and never overlapped with the latter.

Table 2. *Likelihoods of estimated mean evaluation differences, HDIs and Welch's estimates*

Experiment 1 (Recurring elements)

EMD	HDIlo	HDIup	L[d>0]	Welch's *p*	SOA*	Awareness	Alphabet
0.116	-0.005	0.234	97%	0.025	100ms	High	English
0.185	0.090	0.292	100%	0.000	200ms	High	English
-0.015	-0.125	0.103	40%	0.647	400ms	High	English
-0.017	-0.125	0.097	38%	0.804	100ms	Low	English
0.013	-0.074	0.093	61%	0.668	200ms	Low	English
0.186	0.081	0.294	100%	0.001	400ms	Low	English
0.047	-0.065	0.148	81%	0.251	100ms	Partial	English
0.026	-0.044	0.098	76%	0.359	200ms	Partial	English
0.111	0.031	0.194	100%	0.004	400ms	Partial	English
0.106	-0.062	0.263	90%	0.089	100ms	High	Phoenician
0.139	0.046	0.228	100%	0.001	200ms	High	Phoenician
0.017	-0.080	0.119	63%	0.761	400ms	High	Phoenician
0.011	-0.079	0.104	60%	0.796	100ms	Low	Phoenician
-0.004	-0.093	0.094	47%	0.920	200ms	Low	Phoenician
0.174	0.054	0.304	100%	0.004	400ms	Low	Phoenician
0.036	-0.060	0.125	78%	0.338	100ms	Partial	Phoenician
0.008	-0.087	0.106	56%	0.875	200ms	Partial	Phoenician
0.133	0.050	0.217	100%	0.001	400ms	Partial	Phoenician

Experiment 2 (No recurring elements)

EMD	HDIlo	HDIup	L[d>0]	Welch's *p*	Condition**	Awareness	Alphabet
-0.015	-0.054	0.023	23%	0.561	English	High	English
0.049	0.019	0.079	100%	0.000	English	Partial	English
0.039	-0.001	0.080	97%	0.038	English	Low	English
0.029	-0.005	0.065	95%	0.011	Phoenician	High	Phoenician
0.056	0.025	0.089	100%	0.000	Phoenician	Partial	Phoenician
0.034	-0.005	0.070	96%	0.021	Phoenician	Low	Phoenician

All statistically significant ($p < .04$) and extremely likely ($L > 90\%$) differences have been highlighted.
* Participants in Experiment 1 were exposed to 100/200/400 ms SOAs during conditioning, and viewed exemplars from both Phoenician and English categories during conditioning and evaluation phases.
** Participants in Experiment 2 viewed English *or* Phoenician strings during conditioning and evaluation phases (details in manuscript).

Table 3. *Likelihoods of posterior - prior mean hit differences*

Experiment 1 (Recurring elements)

Prop.Mean	Prop.SD	HDIlo	HDIup	L[>prior]*	SOA	Awareness	Alphabet
0.514	0.021	0.473	0.555	98%	100ms	High	English
0.450	0.020	0.411	0.489	0%	200ms	High	English
0.531	0.022	0.488	0.574	100%	400ms	High	English
0.433	0.016	0.402	0.465	70%	100ms	Partial	English
0.500	0.017	0.466	0.534	86%	200ms	Partial	English
0.514	0.015	0.485	0.542	100%	400ms	Partial	English
0.521	0.018	0.485	0.556	100%	100ms	Low	English
0.481	0.017	0.449	0.516	100%	200ms	Low	English
0.388	0.019	0.351	0.426	0%	400ms	Low	English
0.556	0.020	0.516	0.596	100%	100ms	High	Phoenician
0.500	0.020	0.462	0.540	97%	200ms	High	Phoenician
0.469	0.022	0.426	0.512	0%	400ms	High	Phoenician
0.500	0.016	0.468	0.531	15%	100ms	Partial	Phoenician
0.510	0.017	0.476	0.543	86%	200ms	Partial	Phoenician
0.493	0.015	0.463	0.522	92%	400ms	Partial	Phoenician
0.458	0.018	0.424	0.494	0%	100ms	Low	Phoenician
0.452	0.017	0.419	0.488	29%	200ms	Low	Phoenician
0.512	0.020	0.472	0.549	90%	400ms	Low	Phoenician

Experiment 2 (No recurring elements)

Prop.Mean	Prop.SD	HDIlo	HDIup	L[>prior]	Condition	Awareness	Alphabet
0.572	0.007	0.558	0.585	100%	English	High	English
0.557	0.006	0.546	0.568	100%	English	Partial	English
0.545	0.007	0.531	0.559	100%	English	Low	English
0.492	0.008	0.477	0.507	100%	Phoenician	High	Phoenician
0.502	0.006	0.491	0.513	100%	Phoenician	Partial	Phoenician
0.502	0.006	0.490	0.514	0%	Phoenician	Low	Phoenician

* Likelihoods of posterior hits being proportionately greater than priors informed through pre-conditioning hit distributions.

Table 4. *Memory check performances*

Experiment 1					
English		Phoenician		Awareness	SOA
Hits	*Misses*	Hits	*Misses*		
128	*0*	129	*0*	High	100ms
190	*0*	204	*0*	Partial	100ms
148	*32*	162	*22*	Low	100ms
133	*7*	133	*0*	High	200ms
175	*5*	175	*11*	Partial	200ms
168	*10*	174	*1*	Low	200ms
109	*7*	109	*15*	High	400ms
232	*13*	232	*10*	Partial	400ms
128	*29*	137	*28*	Low	400ms
Experiment 2					
English		Phoenician		Awareness	Alphabet/ Condition
Hits	*Misses*	Hits	*Misses*		
		302	*29*	High	Eng-Eval
		341	*8*	Partial	Eng-Eval
		210	*21*	Low	Eng-Eval
315	55			High	Pho-Eval
613	130			Partial	Pho-Eval
437	164			Low	Pho-Eval

Free selections of grammars which had (not) appeared as CS were scored as hits (misses) respectively. Across Experiment 2 (bottom panel), participants viewed either English CS (*Pho-Eval*) or Phoenician CS (*Eng-Eval*) during conditioning. Consequently, participant sub-groups had to select between Phoenician CS/distractors *or* English CS/distractors.

Supplementary Table A. Self-reported evaluative strategies

100 ms
High-Awareness
number of letters kept changing
Tried to recognize the patterns of certain words
I selected mostly those that were short
Partial-Awareness
i remember the style of the word and how the letters were arranged
there were similar letters
Most words grouped together looked familiar
Tried to identify by the shape like square and noticing similar patterns of words like VTTRM or XVTRTRM
I made sure to select the word that had "VV" in the beginning
Low-Awareness
Simultaneously recalling the recurring symbols from the earlier seen words whilst elimiating the unfamiliar ones such as "Z" and other letters that did not show up.
remembering the specific letter and images
Just cram it.
Remembered the specific vocabs used.
By remebering the same letters which were repeated e.g VVVNX
200 ms
High-Awareness
just see the letters in my name
Not sure. But the more I saw the words, the more I remembered
I think some words that went with happy
some words looked the same
only by looking at the word available
Partial-Awareness
I just went with the word that made me feel comfortable. With the image part, I didn't blink.
I just recalled to find familiar words.
Recalling the letters that co-exist.
Remembering the words by the symbols given
Letter MV always present in the words
Recalling the letters which were common
Low-Awareness
I realized that words I may have seen before were on one side of the column. However I am uncertain whether all the words on the same column were familiar.
Just remembered some patterns

The type of font and symbols used were helpful in identifying the words I saw.
Looked out for the symbols and most common alphabet
For the letter combinations, I was more inclined to select the ones without or less X's. For the 'words' containing figures, I preferred the ones with less boxes or straight lines, and chose the option with more curves or circles presented.
Photographic memory
400 ms
High-Awareness
selecting the x in word
Partial-Awareness
double word and triple word
I look at the first two letters and the last two letters
awesome
recall
it seemed that there were specific letters like X that i didnt like so i was mostly choosing words without much those letters.
double letters
looking the same
looking at the shapes and size of letters or shapes
Low-Awareness
momorise the first two letter and the last two letters
repeated letters or symbol
i memorised the wordsin my head and chose the ones that looked similar
the design or look of the symbols and the meaning i associated with the letters
I just group the letters i like/continously see together, and i pick out the shortest words to remeber.
observations of X
Pho-Eval
High-Awareness
I didn't have idea of what i was going to get asked :(
For the symbolsI jsut keptrepeatingthe one I saw
... that was bad
it seemed pretty too hard
Clicked the ones that I seemed to vaguely remember
Partial-Awareness
The strategy was just "is this familiar?", went very much with a gut feeling
I remember seeing more "boxy" letters with sharp angles
i was trying to remember the signs
I did not really remember the words, but I remembered some of the letters I saw, so if a word had them, I selected it.

i remember some of the figures but not really the order

starting with X is bad, V is good (for the second evaluation)

I just tried to remember symbols that were used frequently. Some combinations reminded me of an equation.

I excluded what i didn't remember for sure. also i tried to pick the length of words that i think there were...

It was just what I could recallfrom what I saw I was paying attention to the color and shapes.

I recognized one symbol, the kanji for "day" in Japanese.

Randomly scrambled arrangement

I chose the shortest words and also prioritizing the letter "V"

When selecting words I 'preferred' I spoke them aloud and selected words which seemed to be most pronounceable

Intuition

If the world is long or not and i remember some characters

I think i remember some of them by their specific "language" (?)

I chose the shapes I remembered but I am not sure about any combinations. I didn't see the shapes in the other column before so I went with all those which seemed familiar

I prefer smaller words

I tried to memorize the "letters" but it was really hard because they disappeared really fast

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Low-Awareness

The 2 columns had different "text type" and I remembered only one of them so I only considered those words.

evaluating which i liked better? mostly didn't like when the smae letter was repeated right after itself too many times

I tend to like shorter words

The different shapes of the letters were a lot more of what I'd call aggressive and that was what I went by when choosing them.

I liked shorter words better and also preferred words that had the same letters consecutively

Didn't care for the X's unless the word was very simple, even if long. The V can be used as an U therefore the words make more sense

I remembered to saw a lot of squares in the test, so I select the words with squares

I liked the words that were at least a little bit pronounceable. If the word was hard to pronounce, I decided I didn't like it.

I found this task quite difficult - the small flags appeared very prominent to me in the earlier study. Because of this I decided to choose the words containing small flags.

I like more words that are short

I have good memory

I generally tried to choose shorter words over the long ones, aswell those which had less random X in between other characters. I also took much more liking to words which multiples of the same character in a row eg. "VMMMXV" etc.

I tried do know a few of the symbols and tried to assocciate those to remember

I liked words starting with V more than X and shorter words.

Type of caligraphy and certain patterns

I carefully picked the words that sound better as I called it.

Eng-Eval
High-Awareness
only remember seeing v's and z's in the words but couldnt remember the orders so i just guessed ones with v and z
I just choose what words had X's, no strategy
couldn't recognize them
Partial-Awareness
I remembered letters
Say the word out loud
I remember that the letter that appared the most were V, T and X, maybe M, so I chose every word with a V in it
I don't recall any Z or w. Just VTR and M
I chose words that would be easier for me to remember.
I had a general sense that it involved certain combinations (e.g. V & T)
There were words with "v" letter.
photographic memory
My "strategy" was to like or prefer words that didn't have many repeated symbols side by side
It's not so much of a strategy, but i closed my eyes, and tried to connect some of the words to the faces and see what i can remember
Went with gut feeling.
I tried to remember the first 2 letters of each word and the last letter
Low-Awareness
They went really fast, atleast in my case, so it was really hard trying to remember words. I tried memorizing which letters were repeated the most, and also tried memorizing some of the smaller words.
I just rated higher unfamiliar words that featured more round symbols. The amount of certain symbols and their separation also affected the score.
try to choose the words that i remember see the most
I looked at how many types of letter each word had, whether it had a specific pattern, and if the word looked symmetrical.
Remembering that most of the words finished with an M
How many times the same characters appeared side-by-side at. Too many (like 3?) is bad
I followed my gut feeling
I decorated the first three letters and in the big words tried to record the middle pattern.
Well i do remember VTXRM to be part of the word, i dont remember exactly the order, if the order matters i didn't look at it
I remember seeing a lot of 'x's, so I chose ones with this letter in.
using V and Z as they were prevalent with the words I saw...I have no idea of the faces however
I tried to remember the patterns of the words while focusing on the dots and triangels.
Remember the letters that I didn't see