Root-letter priming in Maltese visual word recognition

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Introduction

- What role does **morphology** play in visual word recognition?
- One possibility is that word recognition is sensitive to morphology:
  - Readers store individual morphemes lexically;
  - Readers decompose complex words into their constituent morphemes during word processing.
- We report on a Maltese visual masked priming study supporting:
  - a level of morphological representation in the Maltese lexicon;
  - the existence of representations for abstract morphemes which readers CANNOT have prior exposure to, but to which exposure can activate said representations and prime related words.

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Morphological Processing

- Support for decomposition comes from **morphological priming**: word recognition can be facilitated by prior exposure to a morphological relative (e.g. Marslen-Wilson et al. 1994; see Amenta and Crepaldi 2012 for review).
- Morphological priming occurs between semantically opaque relatives (e.g. *submit* ~ *PERMIT*) (Forster and Azuma 2000).
- Morphological priming occurs between apparent morphological relatives (e.g. *corner* ~ *CORN*) (Rastle et al. 2004).
  - Readers decompose words on the basis of apparent orthographic decomposability (e.g. *corner* → *corn* + *-er*).
  - No priming for words lacking an apparent relationship (e.g. *BROTHEL* ~ *broth*).

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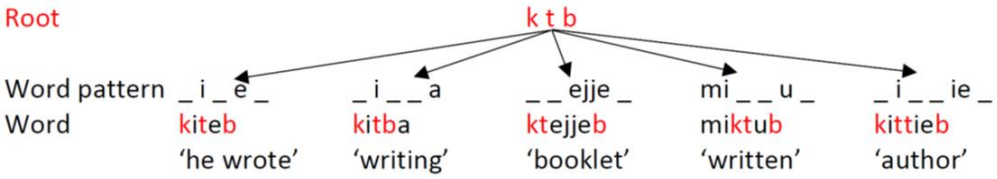
Morphological Processing: Semitic

- Semitic "root-and-pattern" morphology provides a stringent test case for the role of morphology in visual word recognition.
- In Semitic, each word consists of two discontinuous morphemes:
  - a triconsonantal **root** (e.g. *k-t-b*);
  - a consonantal and vocalic **word pattern**.
  - Consider the following examples from Maltese:



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Morphological Processing: Semitic

- Previous studies have likewise observed morphological priming between words containing these Semitic morphemes:
  - **Hebrew:** Frost et al. (1997, 2000) observed **root priming** for nouns and most kinds of verbs; Deutsch et al. (1998) found **word pattern priming** for verbs (but not for nouns).
  - **Arabic:** Boudelaa and Marslen-Wilson (2001, 2004, et seq.) found **root priming** and **word pattern priming** in nouns.
  - **Maltese:** Twist (2006) found **root priming** for verbs.
- Conclusion: Hebrew, Arabic, and Maltese readers recognize words via their roots; evidence for word patterns is more fragile.

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Morphological Processing: Semitic

- In Experiments 2-3, Frost et al. (1997) found that subliminal exposure to Hebrew **root-letters** in isolation primes morphological derivatives, suggesting that these morphemes are directly lexically represented.
  - e.g. *zmr* זמר primes *ti**zm**o**r**et* תזמורת.
- However, Hebrew is written using an **abjad** (i.e. primarily consonants alone are orthographically represented), wherein triconsonantal letter strings can and often do comprise words (e.g. *zamar* זמר 'singer').
  - Frost et al. found that root-letter priming held regardless of prime lexicality, but perhaps Hebrew readers maintain representations even for such non-word strings because of their possible word status…
- More compelling evidence could come from **Maltese**…

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Why Maltese?

- Maltese is a Semitic language, possessing the same **nonconcatenative morphology** as other Semitic languages (Borg and Azzopardi-Alexander 1997).
- Maltese is written using the **Latin alphabet**, so triconsonantal letter strings (e.g. root morphemes) necessarily comprise non-words.
  - Speakers do not encounter such strings in everyday language use.
  - The existence of mental representations for root-letters cannot be due to their status as "possible words" (cf. Hebrew).
- Maltese possesses a split lexicon: ~60% of words are **non-Semitic** (i.e. Italian, Sicilian, English) loans (Bovingdon and Dalli 2006, Brincat 2011).
  - For such words, triconsonantal letter strings are non-morphological.

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Current Study

- We conducted a visual masked priming lexical decision task in which **Semitic-origin** targets were primed by their **root-letters** in isolation.
- To assess whether priming was due to **morphological overlap** and not simply due to **form overlap**, an equivalent number of triconsonantal **non-Semitic** words primed by an equivalent (but non-morphemic) triconsonantal letter string were also included in the experiment.
- If root priming in Maltese is morphological, and if roots are lexically represented, we should observe facilitation when Semitic targets (but not non-Semitic targets) are primed by their root-letters.

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Participants and Materials

- Data from 73 native speakers of Maltese was analyzed.
- Participants judged the lexicality of 192 visual targets. This included:
- 96 real words: 48 Semitic, 48 non-Semitic.
  - Matched according to frequency (Borg et al. 2012);
  - Contained 5-7 letters total;
  - Contained at least three consonant letters.
- 96 non-words: A non-word counterpart was constructed for each real-word target by replacing its "root" with a nonce root.
  - Non-Semitic: the "root" = the three consonants occurring in the target.

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Materials

- Each **real-word target** was matched with four different primes:
  - **Repetition** e.g. *firex* ~ *FIREX* 'to spread'
  - **Root-Letter** e.g. *frx* ~ *FIREX*
  - **Two-Letter** e.g. *grx* ~ *FIREX*
    - 2/3 root-letters (relative linear order preserved), plus a non-root letter.
    - This condition was included as an additional phonological control.
  - **Control** e.g. *qtl* ~ *FIREX*
    - 3 consonant letters which did not occur in the target word.
- Each **non-word target** was matched with a single "root"-letter prime.
  e.g. *ħmk* ~ *ĦIMEK*

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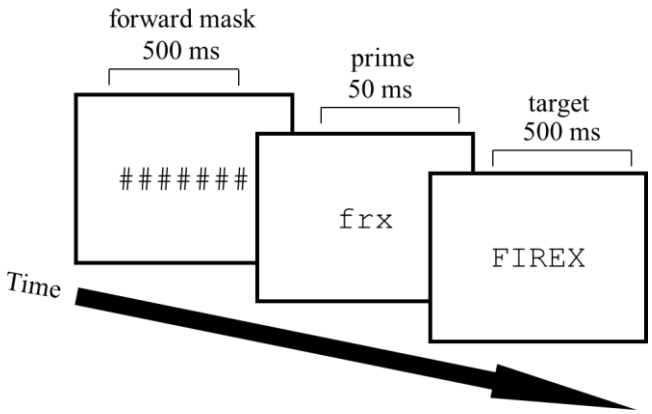
Procedure

- The experiment was conducted in DMDX (Forster and Forster 2003) using the **visual masked priming paradigm** (Forster and Davis 1984).



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Statistical Analysis

- Data for 6 non-Semitic targets was omitted from the analysis because of low overall accuracy rates (i.e. < 50%).
- RTs were analyzed using a REML-fitted linear mixed effects regression (lmer) analysis in R using the lme4 package (Bates et al. 2015).
  - m <- lmer(-1/RT ~ **primingCondition * lexicalStratum** + logFrequency + age + trialNumber + (1|Subject) + (1|Target))
  - **primingCondition**, 4 levels: Repetition, Root-Letter, Two-Letter, Control;
  - **lexicalStratum**, 2 levels: Semitic, non-Semitic.
  - The lmerTest package (Kuznetsova et al. 2016) was used to compute *p*-values using Satterthwaite approximations to degrees of freedom.

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Predictions

- Assuming we observe priming in the **Root-Letter** condition:

1. If root priming is morphological, with root-letters being represented in the Maltese lexicon such that they can be activated/can prime:
   - subjects should be faster to respond to **Semitic** targets (but not to **non-Semitic** targets) when primed by their **root-letters**.
2. If this priming is due to form overlap (i.e. non-morphological):
   - equivalent facilitation should be observed for both **Semitic** and **non-Semitic** targets when primed by their **"root"-letters**.

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Results

- Significant effect of **lexical stratum** ($t(141) = 2.20$, $p < 0.05$).
  - Subjects responded faster to **Semitic** than to **non-Semitic** targets.
- Significant effects at the **Repetition** ($t(8285) = -6.60$, $p < 0.001$), **Root-Letter** ($t(8283) = -3.45$, $p < 0.001$), and **Two-Letter** ($t(8283) = -1.96$, $p < 0.05$) levels of **priming condition** (for **Semitic** targets).
  - Subjects responded faster in all 3 non-control priming conditions.
- Significant effects at the **Root-Letter** ($t(8284) = 2.67$, $p < 0.01$) and **Two-Letter** ($t(8286) = 1.98$, $p < 0.05$) levels of the **lexical stratum by priming condition** interaction.
  - Non-significant at the **Repetition** level ($t(8287) = -0.02$, n.s.).

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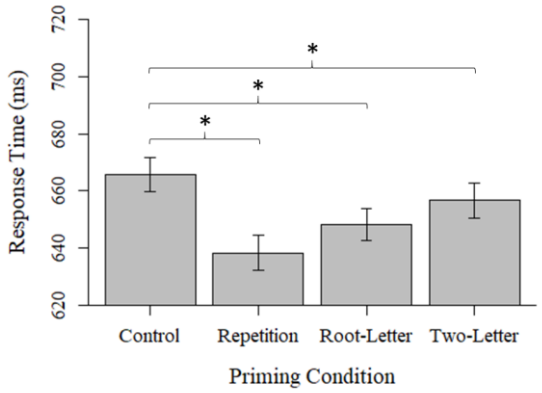
Results: Semitic Targets

- Priming condition: *Mean RT from target onset (+ net priming) in ms.*
  - Control 665.6
  - Repetition 638.3 (27.3) *
  - Root-Letter 648.1 (17.5) *
  - Two-Letter 656.6 (9.0) *



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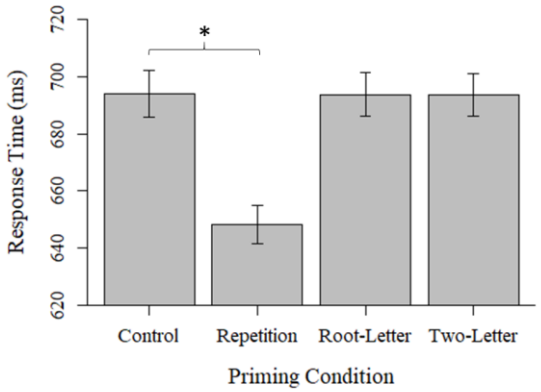
Results: Non-Semitic Targets

- Priming condition: *Mean RT from target onset (+ net priming) in ms.*
  - Control 694.1
  - Repetition 648.2 (45.9) *
  - Root-Letter 693.7 (0.4)
  - Two-Letter 693.5 (0.6)



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Discussion

- Root-letters prime **Semitic** words containing them in Maltese.
- In contrast, triconsonantal letter strings which are not roots do not prime **non-Semitic** Maltese words containing them.
- This suggests that root-letter priming is **morphological**.
  - *Semantic – Root-letters do not mean anything independently.
  - *Phonological – If priming due to form overlap, we would expect facilitation for the non-Semitic targets as well.
- Thus these results further support that visual word recognition in Maltese is sensitive to morphological structure.

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Discussion

- Moreover, these results suggest that root-letters must be represented in the Maltese lexicon in some direct way.
- One possibility is that Maltese readers have abstracted out and stored root morphemes lexically across reading experience.
  - These representations can be activated by exposure to the root-letters in isolation, and can prime words having that root.
  - This is surprising, since root-letters do not occur in isolation in Maltese and so speakers have no need for such representations.
  - cf. Hebrew: root-letters can constitute legal orthographic words.

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Discussion: Two-Letter Priming

- Facilitation was also observed in the **Two-Letter** priming condition, suggesting that partial overlap can activate these representations.
- Two-Letter primes consist of two root-letters, with their relative linear order preserved, plus a third letter. However, there were two types of such primes used in this experiment:
  - **Preserved**: root-letters occur in the same position (e.g. *frx* > *grx*)
  - **Disrupted**: position of the root-letters is disrupted (e.g. *żbr* > *bqr*)
- More work is needed to determine whether position matters, since in this experiment we did not control for position.

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Discussion: Semitic vs. Non-Semitic Targets

- In general, participants were also faster to respond to **Semitic** targets (652.1 ms) than **non-Semitic** targets (682.2 ms). Why?
- One possibility: **Semitic** Maltese words may have more **orthographic neighbors** than do **non-Semitic** words, making them easier to access.
  - Neighborhood density values for the 96 real-word targets used in this study were obtained from the PsyCoL Maltese Lexical Corpus.
  - The results of a Welch's *t*-test suggest that the Semitic and Non-Semitic targets do not differ in terms of number of orthographic neighbors ($t(87.85) = 0.53$, $p > 0.05$).
  - Further work is needed to explain this difference.

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Summary

- The results of this experiment support a morphological level in the Maltese lexicon, where the consonantal root is an abstract entity.
- Moreover, they suggest that Maltese readers may abstract out and store root morphemes lexically across reading experience.
  - These root representations can be activated by exposure to the root-letters in isolation, and can prime words having that root.
  - This is despite their never having seen such triconsonantal strings in isolation and deriving no apparent benefit from doing so.

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Grazzi ħafna!
Thank you!