Roots and patterns in Maltese spoken word recognition
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Acknowledgments

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The questions

- How is the Maltese lexicon structured?
- What can psycholinguistic methods contribute to answering this question?
- More specifically, is there evidence from lexical access concerning the traditional nonconcatenative units proposed for other Semitic languages—roots and patterns?
Background: Maltese

Background: Maltese

- Maltese, a Semitic language likely descended from Siculo-Arabic (Borg and Azzopardi-Alexander 1997), is one of two official languages of Malta (the other is English); Maltese became an official language in 1934.

- Maltese is spoken by roughly 400,000 people in Malta, in addition to a population of emigrant Maltese speakers primarily found in Australia, Great Britain, Canada, and the United states.

- Maltese is unique among Semitic languages in a number of ways.
The overwhelming majority of Maltese speakers are bilingual (Maltese and English). In the 2005 census, over 90% of respondents over age 10 report Maltese as the language they speak most often in their home.

Maltese, while clearly genetically a Semitic language, has had virtually no contact with other Semitic languages for hundreds of years, and the country, culture, and national identity are overwhelmingly European (and Roman Catholic).

The vocabulary of Maltese is roughly evenly split between Semitic and Indo-European (primarily Italian and English; e.g., Aquilina 1987/1990, Mifsud 1995).

Maltese orthography uses the Latin alphabet; it is the only Semitic language to do so.
Maltese as a hybrid

- As an example, consider verbs in Maltese, which fall into two general categories: Semitic vs. Indo-European.

  - Semitic: kiteb ‘to write’ t kieteb ‘to correspond’
    kiser ‘to break’  kisser ‘to smash’
    - The Semitic system (see below) recapitulates the traditional binyan/verbal pattern system seen in other Semitic languages (e.g., Arabic, Hebrew).
  
  - Indo-European: ittowja ‘to thaw, trans.’ ittowja ‘to thaw, intrans.’
    - The Indo-European system involves labile alternations, in which argument structure is not encoded via derivational morphology, but rather by explicit word order differences (see Spagnol 2010).
Is there an in-between? Can verbs borrowed into the language relatively long ago ever show Semitic-like characteristics?

Yes! See Mifsud’s (1995) comprehensive survey of Maltese loan verbs; many verbs from Indo-European (Italian only, interestingly) have been integrated into the Semitic system.

E.g.,

baum ‘to make chubby’
tbaum ‘to become chubby’
serp ‘snake’
serrep ‘to zigzag’
pitter ‘to paint’
ptitter ‘to be painted’
## Semitic Maltese

Root: /l s n/ (data from Fabri 2010)

<table>
<thead>
<tr>
<th>Form</th>
<th>Pattern</th>
<th>Meaning</th>
<th>Binyan</th>
</tr>
</thead>
<tbody>
<tr>
<td>lisen</td>
<td>CVCVC</td>
<td>‘talk’</td>
<td>(1)</td>
</tr>
<tr>
<td>lissen</td>
<td>CVCCVC</td>
<td>‘utter/say’</td>
<td>(2)</td>
</tr>
<tr>
<td>tlissen</td>
<td>t-CVCCVC</td>
<td>‘be uttered’</td>
<td>(5)</td>
</tr>
<tr>
<td>(i)lsien</td>
<td>CCVVC</td>
<td>‘tongue/language’</td>
<td></td>
</tr>
<tr>
<td>(i)lsn-a</td>
<td>CCC-a</td>
<td>‘tongues/languages’</td>
<td></td>
</tr>
<tr>
<td>tlissin-a</td>
<td>t-CVCCV-a</td>
<td>‘utterance’</td>
<td></td>
</tr>
<tr>
<td>tlissin</td>
<td>t-CVCCVC</td>
<td>‘uttering’</td>
<td></td>
</tr>
<tr>
<td>lissien</td>
<td>CVCCVVC</td>
<td>‘utterer’</td>
<td></td>
</tr>
<tr>
<td>milsen</td>
<td>m-VCCVC</td>
<td>‘dictionary’</td>
<td></td>
</tr>
</tbody>
</table>
## Indo-European Maltese

Stem: lingw- (data from Fabri 2010)

<table>
<thead>
<tr>
<th>Form</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>lingw-a</td>
<td>tongue-f.sg.</td>
</tr>
<tr>
<td>lingw-i</td>
<td>tongue-pl.</td>
</tr>
<tr>
<td>lingw-a-ġġ</td>
<td>tongue-f.sg.-nom.</td>
</tr>
<tr>
<td>lingw-ist-a</td>
<td>tongue-nom.-f.sg.</td>
</tr>
<tr>
<td>lingw-ist-i</td>
<td>tongue-nom.-pl.</td>
</tr>
<tr>
<td>lingw-ist-ik-a</td>
<td>tongue-nom.-adj.-f.sg.</td>
</tr>
<tr>
<td>lingw-ist-ik-u</td>
<td>tongue-nom.-adj.-m.sg.</td>
</tr>
<tr>
<td>lingw-ist-iċ-i</td>
<td>tongue-nom.-adj.-pl.</td>
</tr>
<tr>
<td>bi-lingw-i</td>
<td>adj.-tongue-adj.</td>
</tr>
<tr>
<td>mono-lingw-i</td>
<td>adj.-tongue-adj.</td>
</tr>
</tbody>
</table>
What does the language sound like?

- Here’s a 20-second clip in Maltese (from a video on a Maltese news service about my ongoing Maltese dictionary digitization project)

- The focus for the rest of this talk will be on the Semitic side of Maltese.
The binyan system of Semitic verbs in Maltese

<table>
<thead>
<tr>
<th>Binyan</th>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (CVCVC)</td>
<td>basic active (transitive or intransitive)</td>
<td>kiser ‘to break’</td>
</tr>
<tr>
<td>2 (CVCCVVC)</td>
<td>intensive of 1, transitive of 1</td>
<td>kisser ‘to smash’</td>
</tr>
<tr>
<td>3 (CieCVC)</td>
<td>transitive of 1</td>
<td>bierek ‘to bless’</td>
</tr>
<tr>
<td>5 (tCVCCVVC)</td>
<td>passive of 2, reflexive of 2</td>
<td>tkisser ‘to get smashed’</td>
</tr>
<tr>
<td>6 (tCieCVC)</td>
<td>passive of 2, reflexive of 3</td>
<td>tkieteb ‘to correspond’</td>
</tr>
<tr>
<td>7 (nCVCVC)</td>
<td>passive of 1, reflexive of 1</td>
<td>nkisser ‘to get broken’</td>
</tr>
<tr>
<td>8 (CtVCVC)</td>
<td>passive of 1, reflexive of 1</td>
<td>ftakar ‘to remember’</td>
</tr>
<tr>
<td>9 (CCVVC)</td>
<td>inchoative, acquisition of a quality</td>
<td>hmar ‘to blush’</td>
</tr>
<tr>
<td>10 (stVCCVC)</td>
<td>originally inchoative</td>
<td>stenbah ‘to awake’</td>
</tr>
<tr>
<td>Q1 (CVCCVVC)</td>
<td>basic active</td>
<td>harbat ‘to ruin’</td>
</tr>
<tr>
<td>Q2 (tCVCCVVC)</td>
<td>passive and/or reflexive of Q1</td>
<td>tharbat ‘to be ruined’</td>
</tr>
</tbody>
</table>
On the surface, the Semitic stratum of Maltese appears to have a robust root-and-pattern structure, just like other Semitic languages. However, it is worth questioning how valid a claim this is for Maltese, in light of:

- Maltese-specific formal arguments that the root-and-pattern system is no longer active/productive (cf. Hoberman and Aronoff 2003).
- Behavioral evidence challenging Hoberman and Aronoff (from both perception and production) that the root is actively part of the lexical organization of the language (Twist 2006).
- Further evidence that speakers also access whole words in lexical retrieval (Ussishkin and Twist 2009).
Twist (2006) carried out two experiments, both of which demonstrated a role for the Semitic root:

- In a visual masked priming experiment, prime-target pairs that share roots facilitate lexical access. Interestingly, prime-target pairs that share a binyan do not facilitate lexical access.

- In a nonce-verb elicitation task, nonce nouns constructed to resemble Indo-European words resulted in Indo-European (concatenative) verb formation, while nonce nouns constructed to resemble Semitic verbs resulted in Semitic (nonconcatenative) verb formation.
Recent work (Francom, Ussishkin, and Woudstra 2009ab; Francom, LaCross, Ussishkin 2010) shows that roots are not evenly distributed across the binyan system.

Interestingly, as shown by Francom et al. 2010, subjective word familiarity judgments reveal no effect of binyan, though word frequency counts do show a significant effect, based on the PsyCoL Lexical Corpus of Maltese.
Correlating corpus with behavioral evidence

- The following figure illustrates binyan population and word familiarity ratings as reported in Francom et al. 2010; note the four most populated binyanim:
Previous psycholinguistic work elsewhere in Semitic

- **Hebrew:**
  - Deutsch, Frost, and Forster (1998) demonstrate for Hebrew that verbs show both root and binyan priming effects in masked visual priming (unlike Hebrew nouns, which only show root priming).
  - Frost, Forster, and Deutsch (1997) report no effect of semantic priming when primes and targets fail to share morphology.
Previous psycholinguistic work elsewhere in Semitic

- **Arabic:**
  - Boudelaa and Marslen-Wilson (2001, 2004), in visual masked priming and cross-modal priming tasks, find:
    - Root priming effects
    - Etymon priming effects
    - Binyan priming effects
  - These effects occur regardless of semantic transparency
  - Boudelaa (p.c.) reports both root priming and binyan priming in an auditory task for both dialectal (Tunisian) and Standard Arabic.
The current studies

- Based on this ongoing work, we attempt here to shed light on lexical processing and retrieval in Maltese to help develop our understanding of its lexical structure and organization.

- We designed and ran a series of spoken word recognition experiments, with the following goals:
  - Extending our general understanding of Maltese roots and binyans.
  - Examining whether auditory-based behavioral studies produce results similar to or different from Twist’s (2006) visual studies.
The current studies

- The experiments reported here use an auditory priming methodology in which Maltese subjects perform lexical decision on a target item after hearing a prime followed by the target (examples will be provided shortly).

- In these prime-target pairs, primes can be:
  - identical to the target
  - morphologically related to the target
  - or completely unrelated to the target.
Hypotheses

- A decompositional theory (McCarthy 1979, among others) predicts form priming effects for prime-target pairs that are morphologically related by sharing a root as well as for pairs that are morphologically related by sharing a binyan.

- Even whole-form storage theories (e.g., Ussishkin 2005) predict that such effects could obtain, since in such theories the "derived-from" relationship holds among morphologically-related words.
Methods

- We carried out two different sets of lexical decision experiments in Maltese:
  - Exp 1a, 1b: Auditory speech priming
    - In these studies, subjects hear prime-target pairs and perform a lexical decision task on each target.
  - Exp 2a, 2b: Subliminal speech priming
    - In these studies, we use a methodology recently pioneered by Kouider and Dupoux (2005) as an auditory analog of the masked visual priming methodology (e.g., Forster and Davis 1984, Grainger, Colé, Segui 1991), but with masked auditory primes and auditory targets; as in Experiments 1a and 1b, subjects perform a lexical decision task on each target. Further details on the subliminal methodology are given below.
Procedure

- Experiments were run over the month of May, 2010.
- Each of the four experiment had 66-68 subjects.
- No subject participated in more than one experiment.
- Experiments were conducted at the University of Malta Institute of Linguistics, using desktop computers and E-Prime v. 1.x software to present stimuli and record responses.
- Subjects wore headphones to hear stimuli and performed a lexical decision on the target in each prime-target stimulus pair by pressing a button marked IVA (yes) or LE (no) on a serial response box.
- Subjects were instructed to respond as quickly and as accurately as possible to each target, with a time-out of 1500 ms.
- Dependent measures: Reaction time (RT) from target offset, and accuracy
Materials

- Primes and targets were evenly divided and matched between:
  - Real words and nonwords.
  - Each of four binyans (1, 2, 5, 7: those identified by Francom et al. 2010 as the most populated binyans of Maltese).
  - The three priming conditions (counterbalanced, Latin square, repeated measures design).
- All real words were taken from Aquilina (1987/1990), were rated at least 50% familiar in a Maltese subjective familiarity study (Francom et al. 2010), and were vetted three times by a native speaker of Maltese.
- Nonwords were created from nonce roots in licit binyans, vetted three times by a native speaker to prevent false positives based on dialectal forms.
- Prime-target pairs were matched using a Perl script.
  - Automates prime-target pairing.
  - Allows for specifications; e.g., in unrelated pairs, prime and target share no consonants in the same position.
Materials, fillers, and lexical (in)congruency

- In all experiments, subjects responded to 36 real word prime-real word target pairs, balanced evenly across the three priming conditions.

- An equivalent number of nonword prime-nonword target pairs (36) were also included, also balanced evenly across the three priming conditions.

- An equivalent number of nonword prime-real word target pairs (36) and real word prime-nonword target pairs (36) were also included.
Materials and procedure

- All items were recorded by a male native speaker of Maltese.
- Recordings were made in a sound-attenuated booth (Whisper Room) at the Douglass Phonetics Lab at the University of Arizona:
  - Omnidirectional head-mounted Isomax microphone (Countryman Associates)
  - Symetrix Audio 302 pre-amplifier
  - Alesis Masterlink 9600.
- Each item was recorded three times; the best token was chosen by a trained research assistant, manually spliced and labeled using Praat, and extracted with a Praat script.
- Prime-target pairs were concatenated using a Praat script.
- In Experiments 1a and 1b, primes and targets were separated by a 150 ms-ISI (Marslen-Wilson and Zhou 1999).
Experiments 1a, 1b

- Experiment 1a was designed to test whether prime-target pairs sharing a root facilitated lexical access for the target.
- Experiment 1b was designed to test whether prime-target pairs sharing a binyan facilitated lexical access for the target.
- Both Experiments 1a and 1b used supraliminal primes.
- General design: three priming conditions
  - Identity: prime and target are identical.
  - Related: prime and target share a morphological component (a root (1a) or a binyan (1b)).
  - Unrelated: prime and target share neither a root nor a binyan (i.e., they are completely unrelated morphologically).
Experiment 1a: supraliminal priming with roots

In this study, prime-target pairs in the related priming condition share a consonantal root. Primes are supraliminal.

Examples:

<table>
<thead>
<tr>
<th>Prime</th>
<th>Identity</th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>nqafel</td>
<td>‘to be closed’</td>
<td>qafel</td>
<td>‘to close’</td>
</tr>
<tr>
<td>Target</td>
<td>nqafel</td>
<td>nqafel</td>
<td>nqafel</td>
</tr>
<tr>
<td></td>
<td>‘to be closed’</td>
<td>‘to be closed’</td>
<td>‘to be closed’</td>
</tr>
</tbody>
</table>
Experiment 1a: supraliminal priming with roots

- Results (RT; real word prime-real word target)
  - Significant effect of priming condition (identity priming and root-related priming)
    - $F_1(2,134)=25.87, p<.0001$
    - $F_2(2,70)=18.5, p<.0001$
Experiment 1a: supraliminal priming with roots

Results (RT; nonword prime-nonword target)

- Significant effect of priming condition (identity priming only)
  - $F_1(2, 134) = 62.23, p < .0001$
  - $F_2(2, 70) = 36.94, p < .0001$
Experiment 1b: supraliminal priming with binyans

In this study, prime-target pairs in the related condition share a binyan. Primes are supraliminal.

Examples:

<table>
<thead>
<tr>
<th>Prime</th>
<th>Identity</th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>siket</td>
<td>‘to be silent’</td>
<td>kiber</td>
<td>xebbah</td>
</tr>
<tr>
<td>'to grow'</td>
<td>‘to be silent’</td>
<td>‘to assimilate’</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target</th>
<th>identity</th>
<th>related</th>
<th>unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>siket</td>
<td>‘to be silent’</td>
<td>siket</td>
<td>siket</td>
</tr>
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<td>‘to be silent’</td>
<td>‘to be silent’</td>
<td>‘to be silent’</td>
<td></td>
</tr>
</tbody>
</table>
Experiment 1b: supraliminal priming with binyans

- Results (RT; real word prime-real word target)

- Significant effect of priming condition (identity priming only)
  - $F_1(2, 130) = 75.9, p < .0001$
  - $F_2(2, 70) = 46.11, p < .0001$
Experiment 1b: supraliminal priming with binyans

Results (RT; nonword prime-nonword target)

- Significant effect of priming condition (identity priming only)
  - $F_1(2,130)=42.51, p<0.0001$
  - $F_2(2,70)=20.94, p<0.0001$
Experiments 2a, 2b

- Experiment 2a was designed to test whether prime-target pairs sharing a root facilitated lexical access for the target.
- Experiment 2b was designed to test whether prime-target pairs sharing a binyan facilitated lexical access for the target.
- Both Experiments 2a and 2b used subliminal primes.
- General design: three priming conditions
  - Identity: prime and target are identical.
  - Related: prime and target share a morphological component (a root (2a) or a binyan (2b)).
  - Unrelated: prime and target share neither a root nor a binyan (i.e., they are completely unrelated morphologically).
Procedure: subliminal priming

- In the subliminal experiments (2a and 2b), primes are not audible (hence, they are subliminal), following Kouider and Dupoux (2005).
- This achieves an effect intended to be analogous to that found in the masked visual priming literature.
- Subliminal primes are created by durationally compressing the sound file to 35% of its original duration (P(itch) S(ync) O(ver) L(ap) A(dd); pitch stays the same).
- The prime is then masked (backward and forward); masks consist of compressed and reversed sound files.

Image from Kouider and Dupoux (2005:618)
Materials

- All materials in Experiment 2a are identical to those in 1a (priming with roots).
- All materials in Experiment 2b are identical to those in 1b (priming with binyans).
Experiment 2a: subliminal priming with roots

- In this study, prime-target pairs in the related priming condition share a consonantal root. Primes are subliminal (at 35% compression, subjects do not perceive them).

- Examples:

<table>
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<tr>
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<th>Unrelated</th>
</tr>
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<tr>
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<td>nqafel</td>
<td>nqafel</td>
</tr>
<tr>
<td></td>
<td>'to be closed'</td>
<td>‘to be closed’</td>
<td>‘to be closed’</td>
</tr>
</tbody>
</table>
Experiment 2a: subliminal priming with roots

- Results (RT; real word prime-real word target)

  • Significant effect of priming condition (identity priming and root-related priming)
    • $F_1(2, 130) = 3.72, p < .03$
    • $F_2(2, 70) = 3.05, p = .05$

![Graph showing the effect of priming conditions on mean RT](image)
Experiment 2a: subliminal priming with roots

- Results (RT; nonword prime-nonword target)
  - No effect of priming condition
  - $F_1, F_2 < 1$
In this study, prime-target pairs in the related condition share a binyan. Primes are subliminal.

Examples:

<table>
<thead>
<tr>
<th>Prime</th>
<th>Target</th>
<th>Identity</th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>siket</td>
<td>‘to be silent’</td>
<td>‘to be silent’</td>
<td>‘to be silent’</td>
</tr>
</tbody>
</table>
Experiment 2b: subliminal priming with binyans

Results (RT; real word prime-real word target)

- Significant effect of priming condition (identity priming only)
  - $F_1(2,138)=4.15, p<.02$
  - $F_2(2,70)=2.96, p=.05$
• Experiment 2b: subliminal priming with binyans

□ Results (RT; nonword prime-nonword target)

- No effect of priming condition
  - F1, F2 < 1
Assessment: what do these results mean?

- Binyans fail to facilitate lexical access
Assessment: what do these results mean?

- Roots facilitate lexical access
Discussion

- Reconciliation with formal approaches:
  - These results are nuanced enough to fail to support most existing theories of Semitic morphology (not a surprise, given the all-or-nothing nature of these theories).
  - The results are at odds with fully decompositional approaches (e.g., McCarthy 1979, 1981) due to the lack of binyan priming.
  - The results support a model of Maltese lexical organization in which roots form morphological families, consistent with earlier work by Moscoso del Prado-Martin et al. (2005) and Ussishkin et al. (in progress).
Discussion

- Our root priming effects represent the first form priming effects ever documented using the subliminal speech priming technique.
  - Kouider and Dupoux (2005), in their experiment on French, did not find any effect of semantic, morphological, or phonological form priming; they only found an identity priming effect.
  - Davis, Kim, and Barbaro (2010) on English find only identity priming, and only for target words with relatively few phonological neighbors.
Discussion

- According to our results, since root priming is found, the mental lexicon of Maltese (or the Semitic portion of it, in any case) involves elements that are either connected via the root or are themselves roots.

- The results reported here mirror Twist’s (2006) Maltese results in the visual modality.
Discussion

- Caution is warranted here, as our design did not separate:
  - Semantics
  - Morphology
  - Phonology

- All three of these are wrapped up in the consonantal root, and future work needs to be done to determine if one of these bears primary responsibility for our priming results.

- Earlier work in Hebrew and Arabic tentatively suggests we are dealing with morphology here, and not semantics, though since Maltese is behaving distinctly from Hebrew (no binyan priming in Maltese), we can’t know for sure until we run priming studies with semantically related pairs.
Many questions remain unanswered; many future experiments suggest themselves:

- Subliminal speech priming in Hebrew (experiment currently underway)
- Subliminal priming using nonword primes made from real roots
- Etc…
Conclusions

- Spoken word recognition in Maltese is facilitated by roots, but not binyans.
- This needs to be incorporated into any model of Maltese lexical organization and lexical access.
- The results hold for both audible and subliminal primes, and therefore seem to indicate a degree of automaticity of parsing by roots, or root-related activation.
Grazzi ħafna!

Thanks for your time and attention!
As always, feedback is welcome
ussishki@u.arizona.edu
Related (blue) vs. Unrelated (red) by binyan pairs: Exp 1a (supraliminal primes)
Related (blue) vs. Unrelated (red) by binyan pairs: Exp 2a (subliminal primes)