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Supraliminal and subliminal root and binyan priming in Maltese

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Acknowledgments

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Introduction

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- The root and pattern analysis of Semitic is an elegant and simple theory.
- But it is also language-specific, since it cannot clearly be applied to any other languages (including other Afro-Asiatic languages, or Yokuts and Miwok which exhibit tantalizingly similar patterns).
- Formal linguists and psycholinguists differ on the status of root and pattern/binyan morphemes.
- *The Big Question:* How is the Semitic lexicon structured?

Organization

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- Part 1: Background and previous research
- Part 2: Methods and Results
- Part 3: Morphological Priming in Maltese

Part 1: Background and previous research

Are there roots and patterns?

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- Formal linguists are tending towards answering *no* (Bat-El 1994, Ratcliffe 1997, Ussishkin 1999, 2005, 2006, Farwaneh 2007)
- McCarthy (1981) argues for roots but decomposes patterns/binyanim as well.
- Ussishkin (2000) and Bat-El (2003) specifically argue that Semitic is a unique combination of universally attested properties (phonotactic restrictions, minimal/maximal word size, ablaut).

Are there roots and patterns?

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- Psycholinguists tend to answer *yes*.
- Prunet (2006) suggests we look at areas of convergence: linguists arguing for the root and psycholinguistic evidence for the root.
- Specifically, speech errors and reaction time experiments (priming).
- We focus on priming here.

What is priming?

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- Factors affecting behavioral measures
- Exposure to one stimulus (e.g., a word) affects reaction time to a following stimulus (e.g., another word)
- Well-studied visually (cf. Forster and Davis 1984)
- Not nearly as well-studied auditorily

Visual masked priming

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1 ##### 500ms

2 deceive 50ms

3 RECEIVE Decision Time

(cf. Forster and Davis 1984)

Visual masked priming (2)

~~PREPARED~~

E

Visual masked priming evidence in Semitic

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- Hebrew:
 - Deutsch, Frost, and Forster (1998) demonstrate that verbs show both root and binyan priming effects in masked visual priming (unlike 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.

Visual masked priming evidence in Semitic

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- Arabic:
 - ▣ Boudelaa and Marslen-Wilson (2001, 2004), in visual masked priming and cross-modal priming tasks, find:
 - Root priming effects
 - Etymon priming effects
 - Pattern priming effects
 - ▣ These effects occur regardless of semantic transparency
- Boudelaa (p.c.) reports both root priming and pattern priming in an auditory task for both dialectal (Tunisian) and Standard Arabic.
- Boudelaa and Marslen-Wilson (2005) show differential effects of root vs. pattern priming dependent on the duration of prime exposure.

Orthographic confound

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- Semitic languages use orthographies that privilege consonants.

- ▣ Arabic کتب <ktb> [katab]

- ▣ Hebrew ספר <sfr> [sefer]

→ How can we avoid this orthographic confound?

- Maltese *kiteb*: orthography encodes consonants and vowels consistently.
- Auditory methodology: examine *spoken* word recognition

Is Maltese Semitic?

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<i>Binyan</i>	<i>Function</i>	<i>Example</i>
1 (CVCVC)	basic active (transitive or intransitive)	kiser 'to break'
2 (CVCCVC)	intensive of 1, transitive of 1	kisser 'to smash'
3 (CieCVC)	transitive of 1	bierek 'to bless'
5 (tCVCCVC)	passive of 2, reflexive of 2	tkisser 'to get smashed'
6 (tCieCVC)	passive of 2, reflexive of 3	tkieteb 'to correspond'
7 (nCVCVC)	passive of 1, reflexive of 1	nkiser 'to get broken'
8 (CtVCVC)	passive of 1, reflexive of 1	ftakar 'to remember'
9 (CCVVC)	inchoative, acquisition of a quality	hmar 'to blush'
10 (stVCCVC)	originally inchoative	stenbah 'to awake'
Q1 (CVCCVC)	basic active	harbat 'to ruin'
Q2 (tCVCCVC)	passive and/or reflexive of Q1	tharbat 'to be ruined'

Is Maltese Semitic?

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- Hoberman and Aronoff (2003) question the productivity of Semitic morphology in Maltese, but
- Twist (2006) demonstrates a role for the root in production - in a nonce-verb elicitation task:
 - ▣ Nonce nouns resembling Indo-European resulted in Indo-European (concatenative) morphology.
 - ▣ Nonce nouns resembling Semitic resulted in Semitic (nonconcatenative) morphology.
 - ▣ See Twist (2011 - this conference) for further elaboration.

Masked visual priming evidence in Maltese

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- Twist (2006) also found priming evidence:
 - ▣ In a visual masked priming experiment: prime-target pairs that share roots facilitate lexical access.
 - ▣ Prime-target pairs that share a binyan do not facilitate lexical access.

Part 2: The Current Study

Methods and Results

The current studies

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

The current studies

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- Auditory lexical decision task: participants listen to pre-recorded pairs of primes and targets, and decide whether the target is a word of Maltese.
- In these prime-target pairs, primes can be:
 - ▣ identical to the target (hypothesis: **facilitative**)
 - ▣ morphologically related to the target (hypothesis: **potentially facilitative**)
 - ▣ or completely unrelated to the target (hypothesis: no effect)
- Subliminal and supraliminal primes.

Subliminal Speech Priming

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- In subliminal experiments, primes are not consciously perceived by participants, following Kouider and Dupoux (2005); analagous to visual masked priming.
- Subliminal primes compressed to 35% of its original duration (P(itch) S(ynchronous) O(ver)L(ap) A(dd); pitch stays the same).
- The prime is masked (backward and forward); masks consist of compressed *and reversed* sound files.

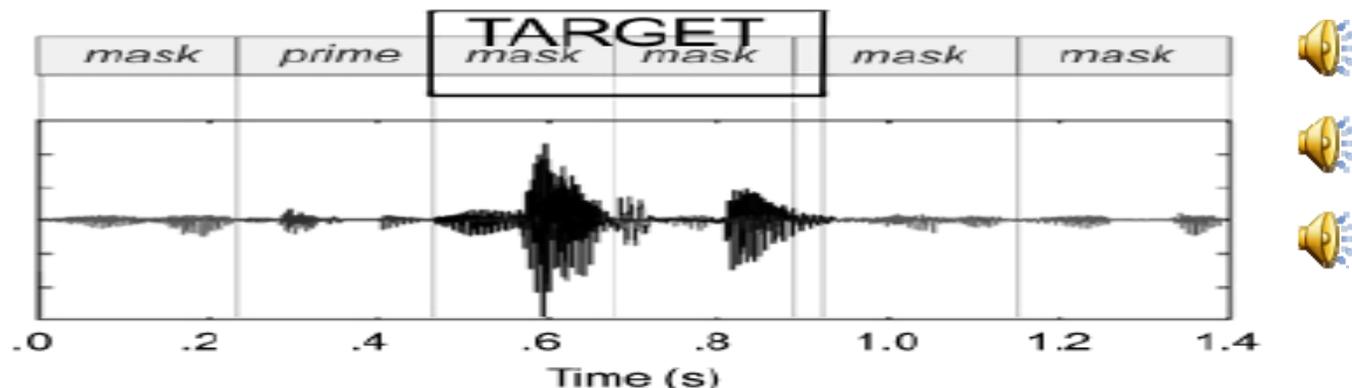


Image from Kouider and Dupoux (2005:618)

Maltese Experiments

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- We carried out two different sets of lexical decision experiments in Maltese:
 - ▣ Exp 1a, 1b: Supraliminal (=auditory) speech priming
 - ▣ Exp 2a, 2b: Subliminal (=masked) speech priming

Materials and Procedure

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- Experiments were run over the month of May, 2010.
- Each of the four experiments had 66-70 subjects.
- No participant participated in more than one experiment.
- Each participant was given 5 euros as compensation for participating
- Experiments were conducted at the University of Malta Institute of Linguistics, using desktop PC computers and E-Prime v.1.2 software to present stimuli and record responses.
- Participants 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.
- Participants 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 and Procedure

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- Primes and targets were evenly divided and matched between:
 - ▣ Real words and nonwords (36 of each for analysis), distributed evenly among...
 - ▣ Four binyanim (1, 2, 5, 7: those identified by Francom et al. 2010 as the most populated binyanim of Maltese), and...
 - ▣ The three priming conditions (counterbalanced, Latin square, repeated measures design) for real word prime-real word target and nonword prime-nonword target pairs.
- 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 restricted such that in unrelated pairs, prime and target share no consonants in the same position.

Materials and procedure

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- 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 labeled and then extracted.
- Prime-target pairs were concatenated with Praat (Boersma and Weenink 2010) and formatted as .wav files for use in the experiment.
- In Experiments 1a and 1b, primes and targets were separated by a 150 ms-ISI (Marslen-Wilson and Zhou 1999).

Experiments 1a, 1b

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

Experiment 1a: Supraliminal priming with roots

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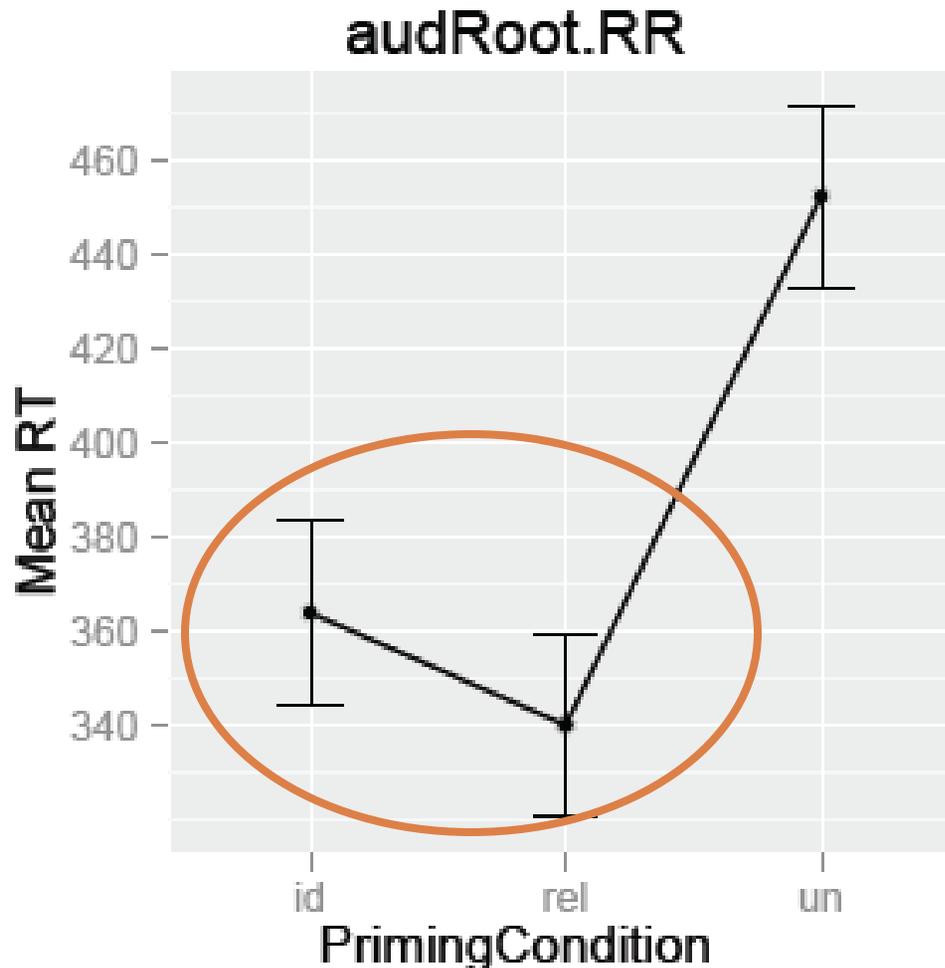
- Prime-target pairs in the related priming condition share a consonantal root. Examples:

	Identity	Related	Unrelated
Prime	nqafel 'to be closed'	qafel 'to close'	fileġ 'to paralyze'
Target	nqafel 'to be closed'	nqafel 'to be closed'	nqafel 'to be closed'
			

Experiment 1a: Supraliminal priming with roots

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



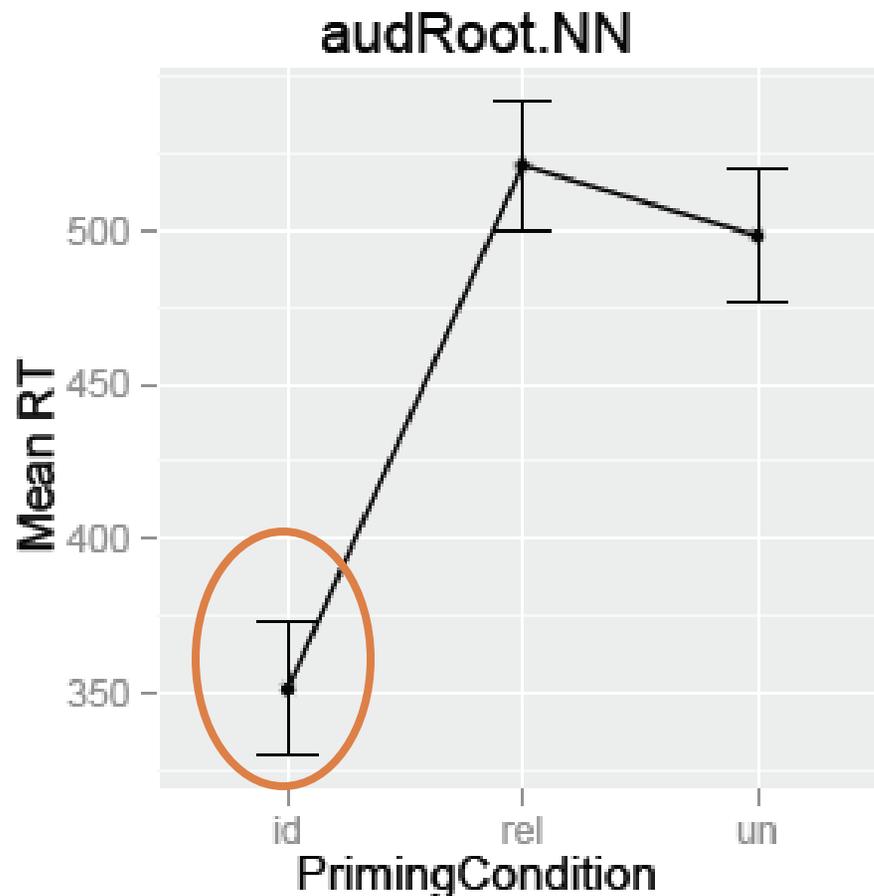
- Significant effect of priming condition (**identity priming** and **root-related priming**)

- $F1(2,134)=25.87, p<.0001$
- $F2(2,70)=18.5, p<.0001$

Experiment 1a: Supraliminal priming with roots

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- Results (RT; nonword prime-nonword target)



- Significant effect of priming condition (**identity priming only**)

- $F(2,70)=36.94, p<.0001$
- $F(2,134)=62.23, p<.0001$

Experiment 1b: Supraliminal priming with binyanim

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- Prime-target pairs in the related condition share a binyan. Examples:

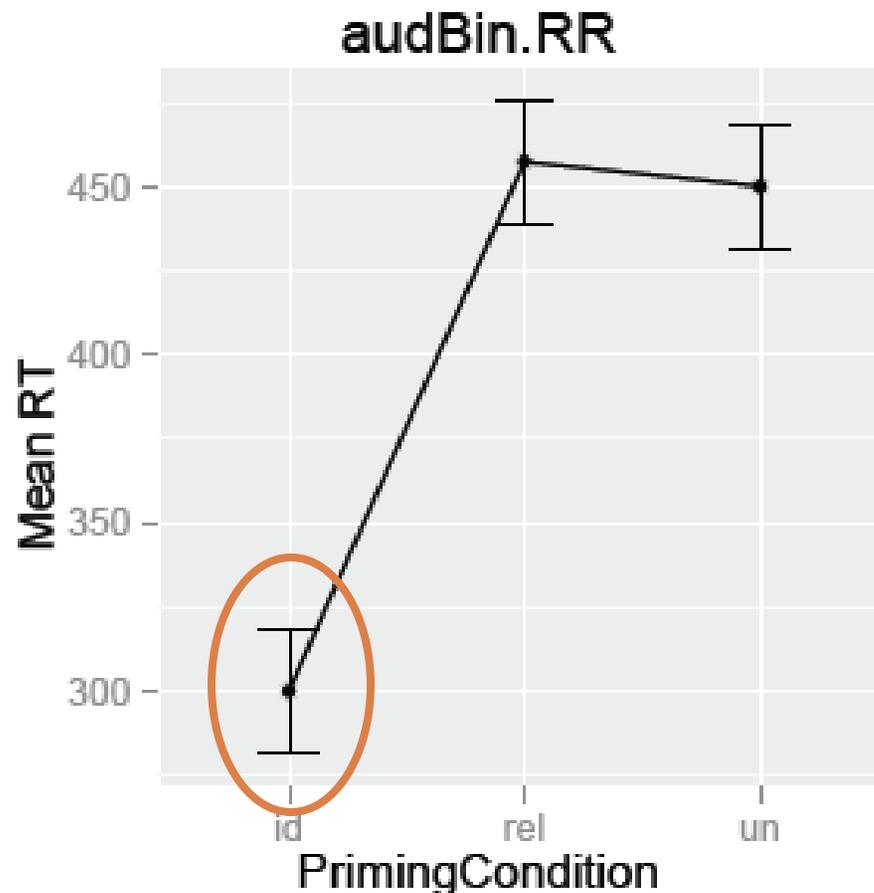
	Identity	Related	Unrelated
Prime	siket 'to be silent'	kiber 'to grow'	xebbah 'to assimilate'
Target	siket 'to be silent'	siket 'to be silent'	siket 'to be silent'



Experiment 1b: Supraliminal priming with binyanim

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



- Significant effect of priming condition (**identity priming** only)

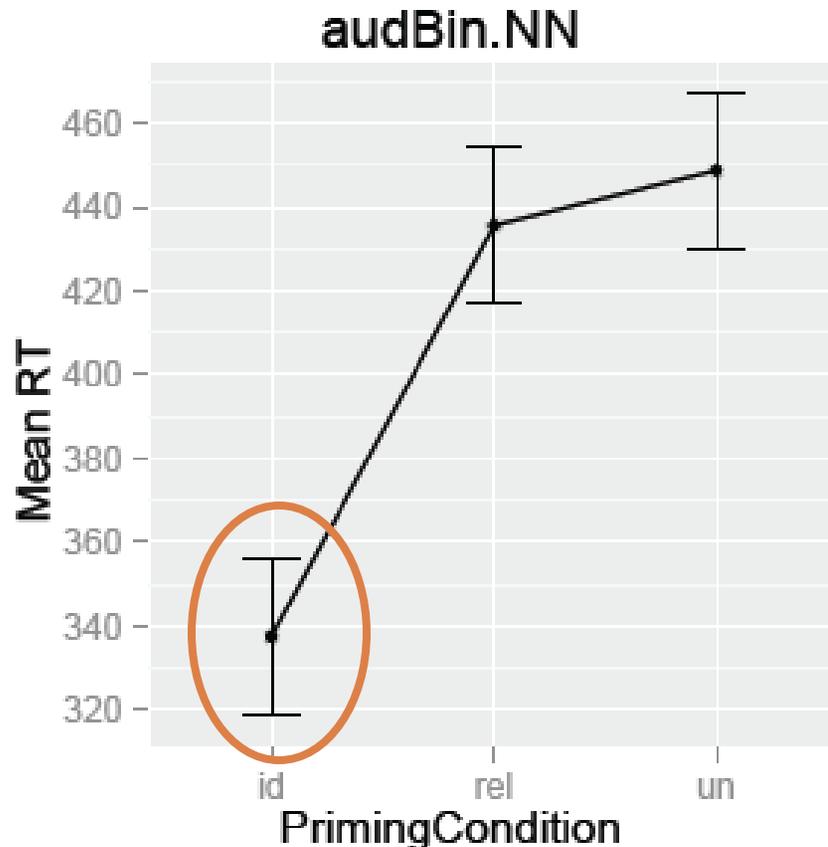
- $F(2,130)=75.9, p<.0001$

- $F(2,70)=46.11, p<.0001$

Experiment 1b: Supraliminal priming with binyanim

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□ Results (RT; nonword prime-nonword target)



- Significant effect of priming condition

(identity priming only)

- $F1(2, 130)=42.51, p<.0001$

- $F2(2, 70)=20.94, p<.0001$

Experiments 2a, 2b

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- Experiments 2a and 2b are identical (same prime-target pairs) to Experiments 1a and 1b except for the method of prime presentation:
- Experiments 2a and 2b use the Subliminal Speech Priming technique (Kouider and Dupoux 2005).
- General design: same three priming conditions

Experiment 2a: Subliminal priming with roots

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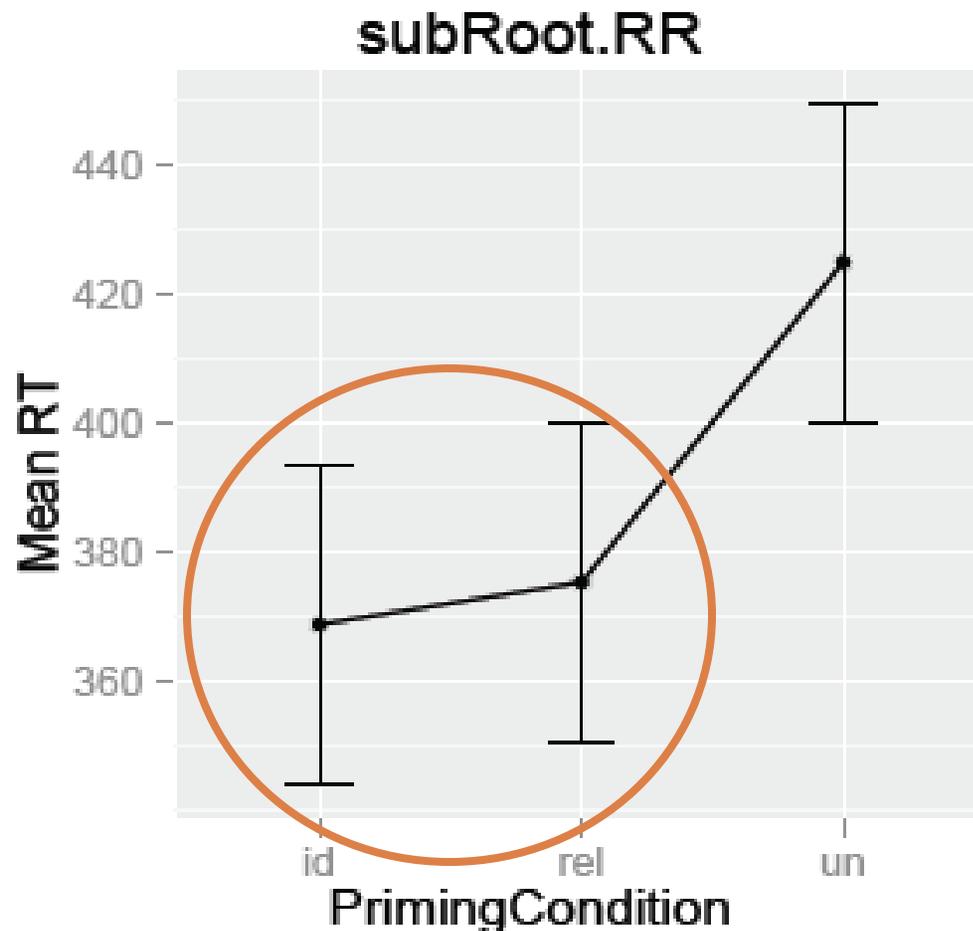
- Prime-target pairs in the related priming condition share a consonantal root. Primes are compressed to 35% of their original duration. Examples:

	Identity	Related	Unrelated
Prime	nqafel 'to be closed'	qafel 'to close'	fileg 'to paralyze'
Target	nqafel 'to be closed'	nqafel 'to be closed'	nqafel 'to be closed'
			

Experiment 2a: Subliminal priming with roots

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

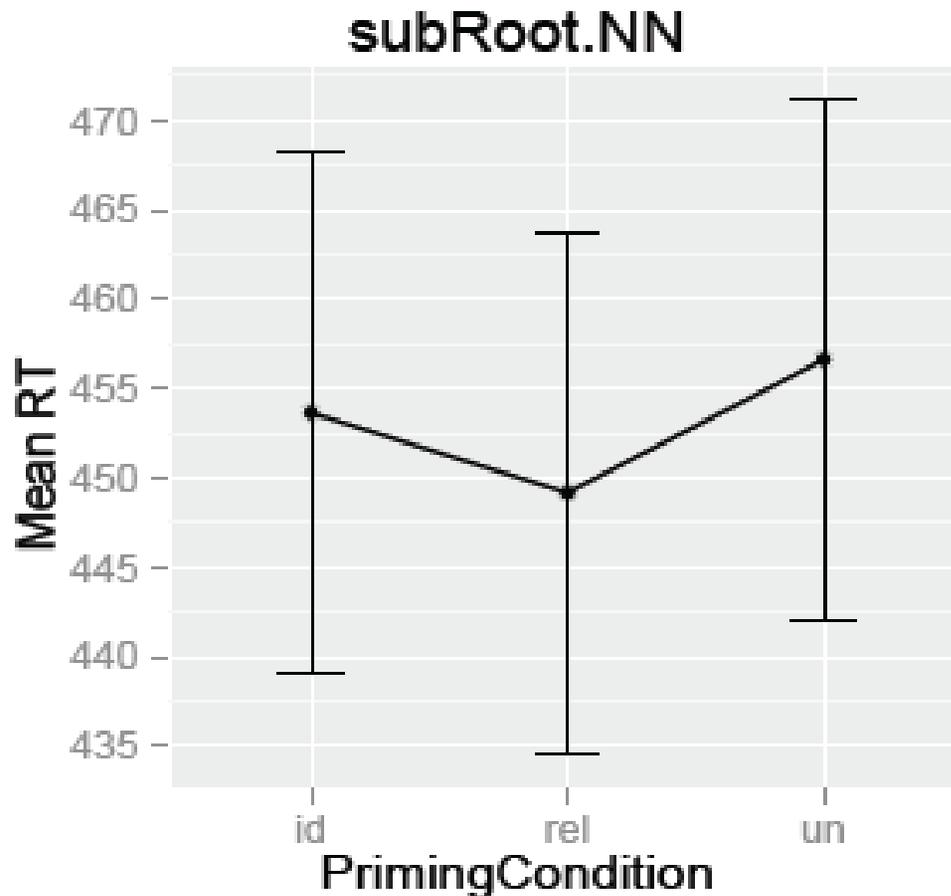


- Significant effect of priming condition (identity priming and root-related priming)
 - $F(2,130)=3.72, p<.03$
 - $F(2,70)=3.05, p=.05$

Experiment 2a: Subliminal priming with roots

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- Results (RT; nonword prime-nonword target)



- No effect of priming condition
- $F_{1, F2} < 1$

Experiment 2b: Subliminal priming with binyanim

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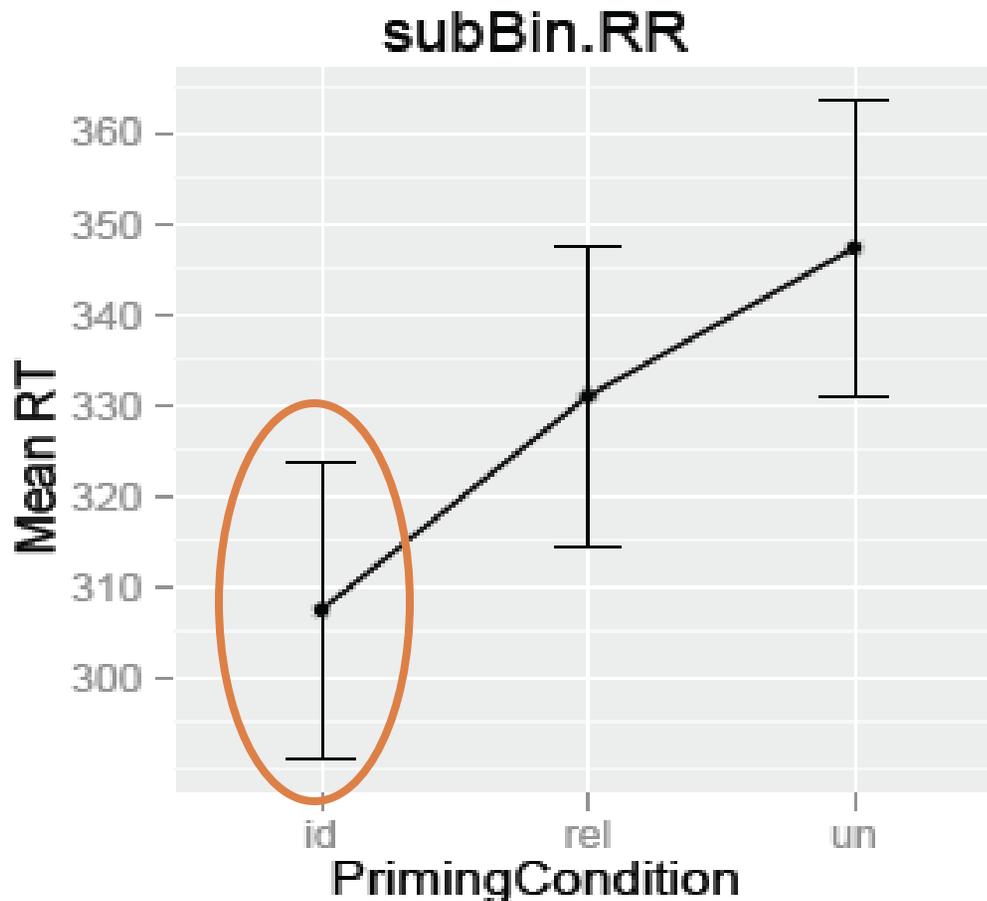
- Prime-target pairs in the related condition share a binyan. Primes are subliminal. Examples:

	Identity	Related	Unrelated
Prime	siket 'to be silent'	kiber 'to grow'	xebbah 'to assimilate'
Target	siket 'to be silent'	siket 'to be silent'	siket 'to be silent'
			

Experiment 2b: Subliminal priming with binyanim

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

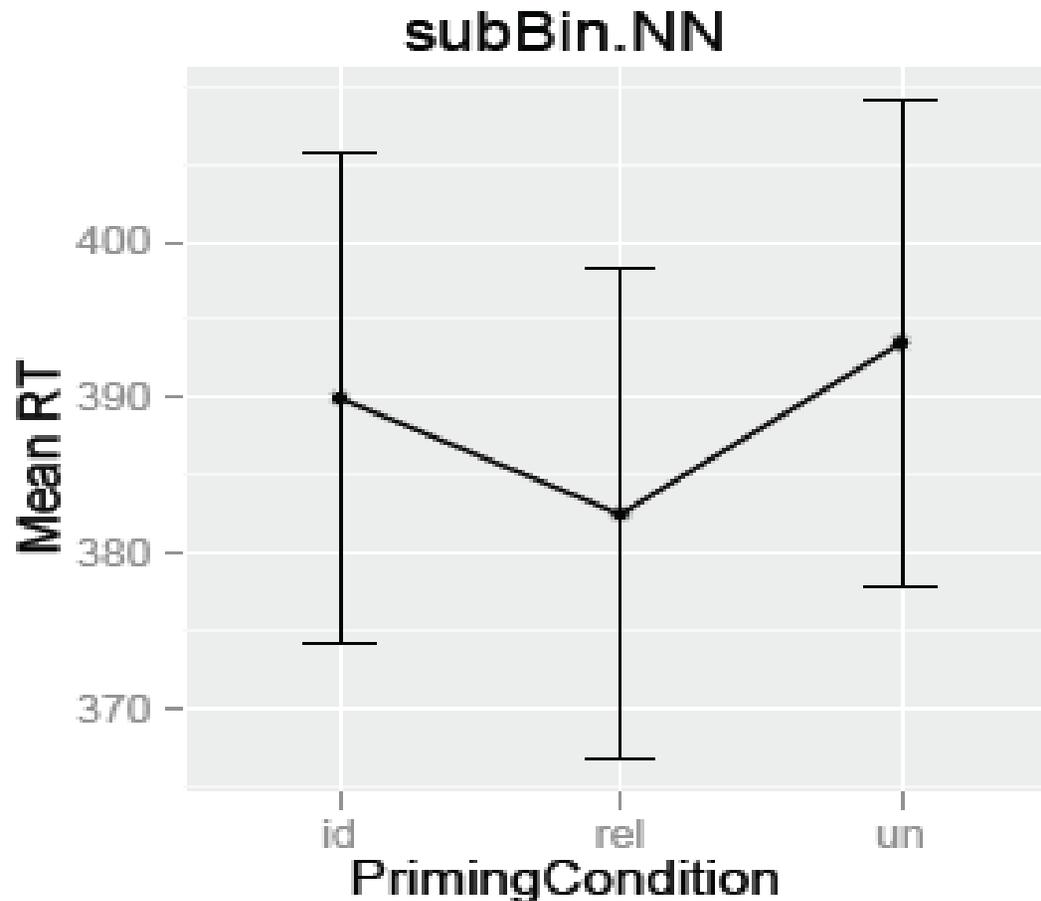


- Significant effect of priming condition (identity priming only)
 - $F(2,138)=4.15, p<.02$
 - $F(2,70)=2.96, p=.05$

Experiment 2b: Subliminal priming with binyanim

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□ Results (RT; nonword prime-nonword target)



- No effect of priming condition
- $F_{1, F2} < 1$

Did our Maltese subjects hear the subliminal primes?

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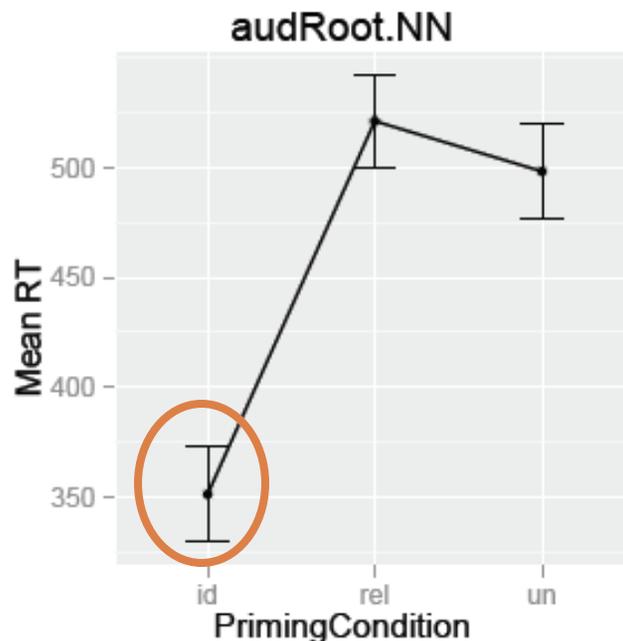
- They did not: Post-experiment debriefing indicates that subjects were not aware of the primes.
 - ▣ Consistent with Kouider and Dupoux (2005).
 - ▣ Typical strategy reported by participants: “I had to pay attention to the thing I could understand [the word], so I didn’t pay attention to the noise.”

Did our Maltese subjects hear the subliminal primes?

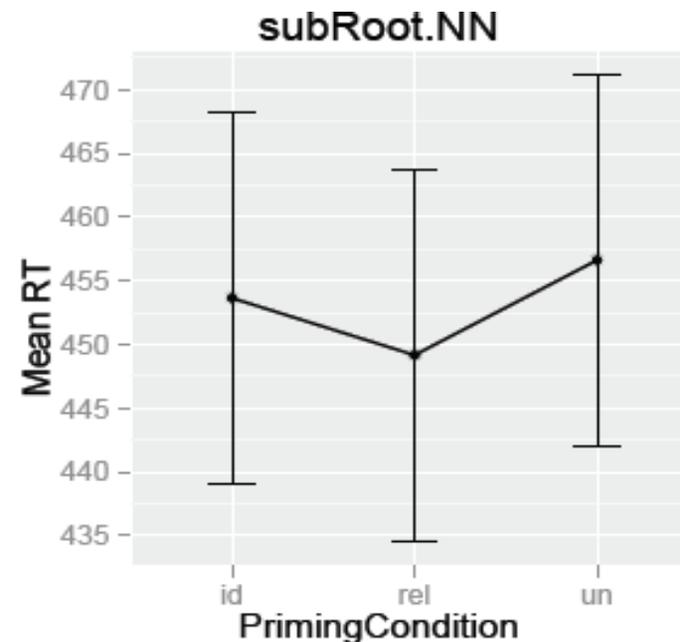
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- Our experimental design provides additional supporting evidence: In nonword-nonword prime-target pairs, subliminal items (Exp 2a and 2b) in the identity condition show no priming, unlike in Experiments 1a and 1b.

Supraliminal primes (Exp 1a):



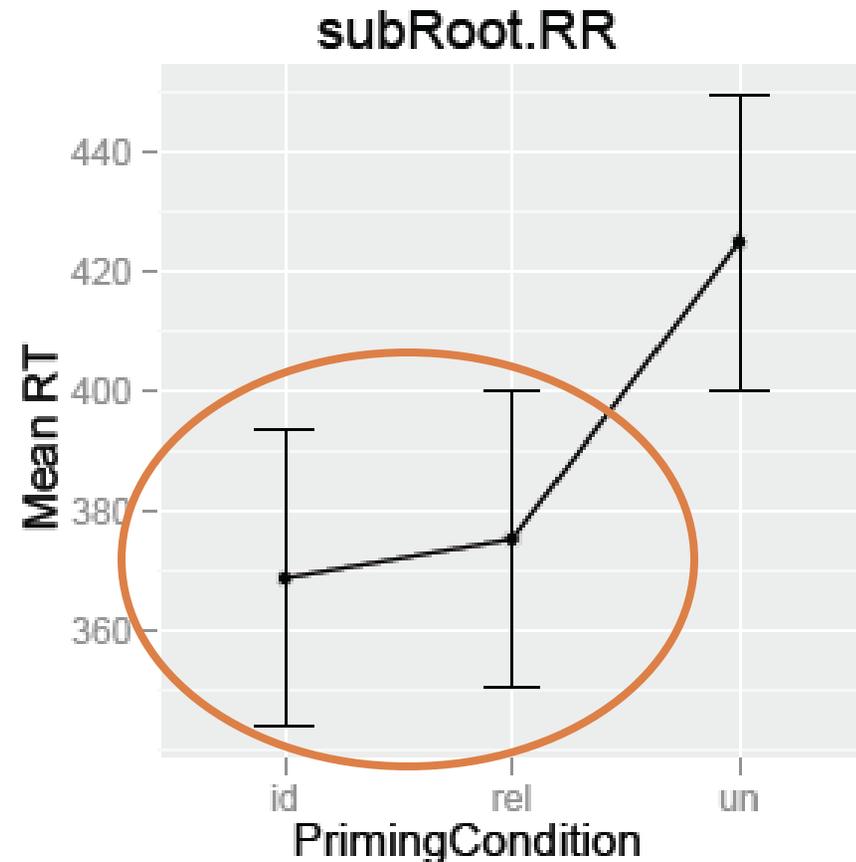
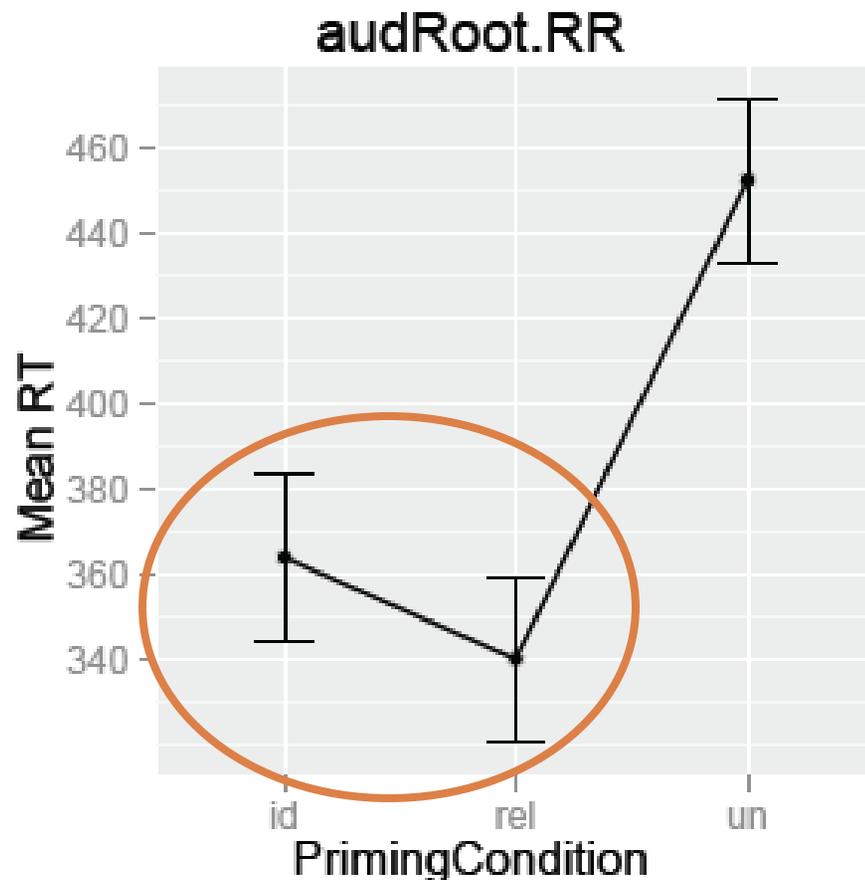
Subliminal primes (Exp 2a):



Assessment: what do these results mean?

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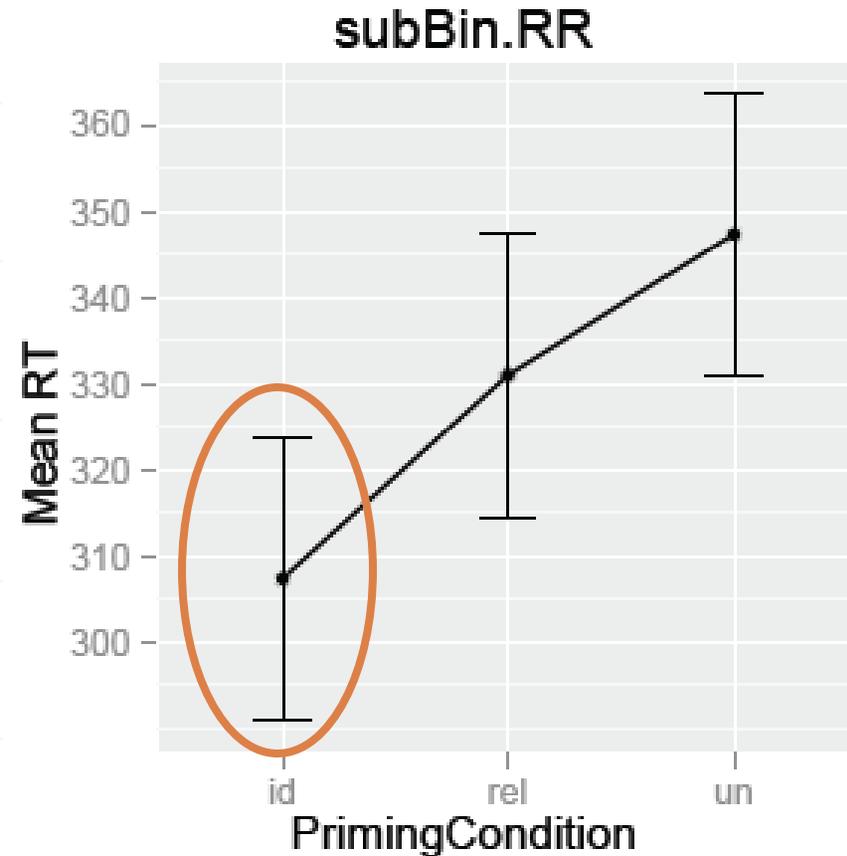
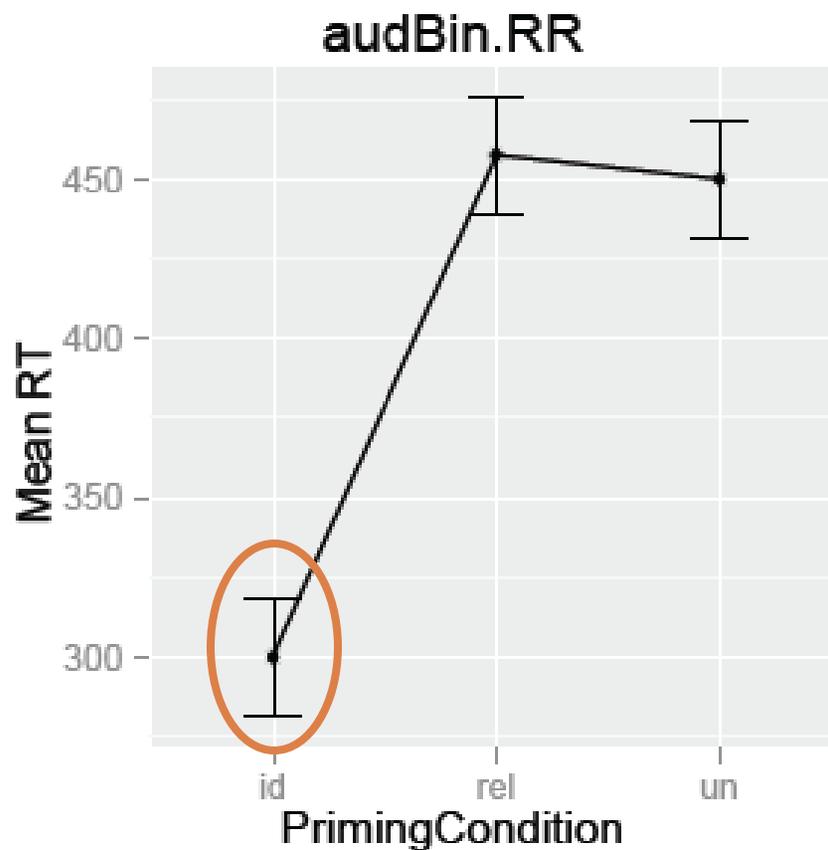
- Roots facilitate lexical access



Assessment: Binyanim?

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- Binyanim fail to facilitate lexical access



Part 3: Discussion

The Maltese lexicon and the Root

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 falsify fully decompositional theories (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

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- Our subliminal 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 for subliminal primes; they only found an identity priming effect.
 - ▣ Schluter (2011) and Davis, Kim, and Barbaro (2010) on English find only identity priming, and only for target words with relatively few phonological neighbors.
 - ▣ Schluter (2011) finds differential effects for natural vs. synthetic speech.

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: root priming, but no binyan priming.

Discussion: how much morphological knowledge can we gain from these results?

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- Mild caution is warranted here, as our design did not separate semantics, morphology, or 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 suggests we are dealing with morphology here, and not semantics.
- Relationship of orthography and binyanim is still uncertain.

Future work

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- Many questions remain unanswered, and many future experiments suggest themselves:
 - ▣ Subliminal speech priming in Hebrew (experiment currently underway)
 - ▣ Subliminal priming using nonword primes made from real roots
 - ▣ Applications of this technique to other Afro-Asiatic languages (e.g., Moroccan Arabic, Amazigh...).
 - ▣ Etc...

Conclusions

- Spoken word recognition in Maltese is facilitated by roots, but not binyanim.
- This needs to be incorporated into any model of Maltese lexical organization and speech perception.
- 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!

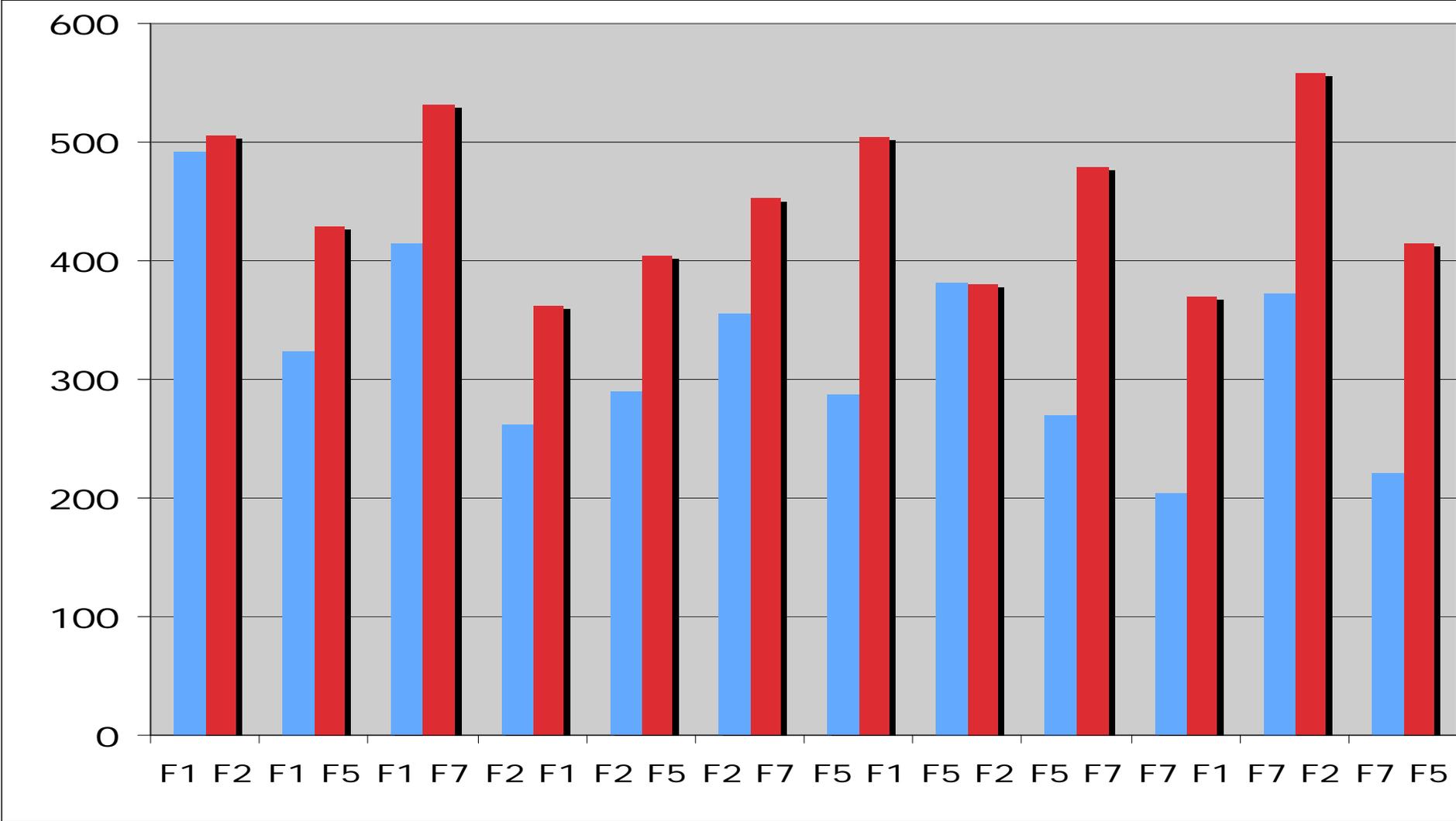
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Thanks for your time and attention!

As always, feedback is welcome

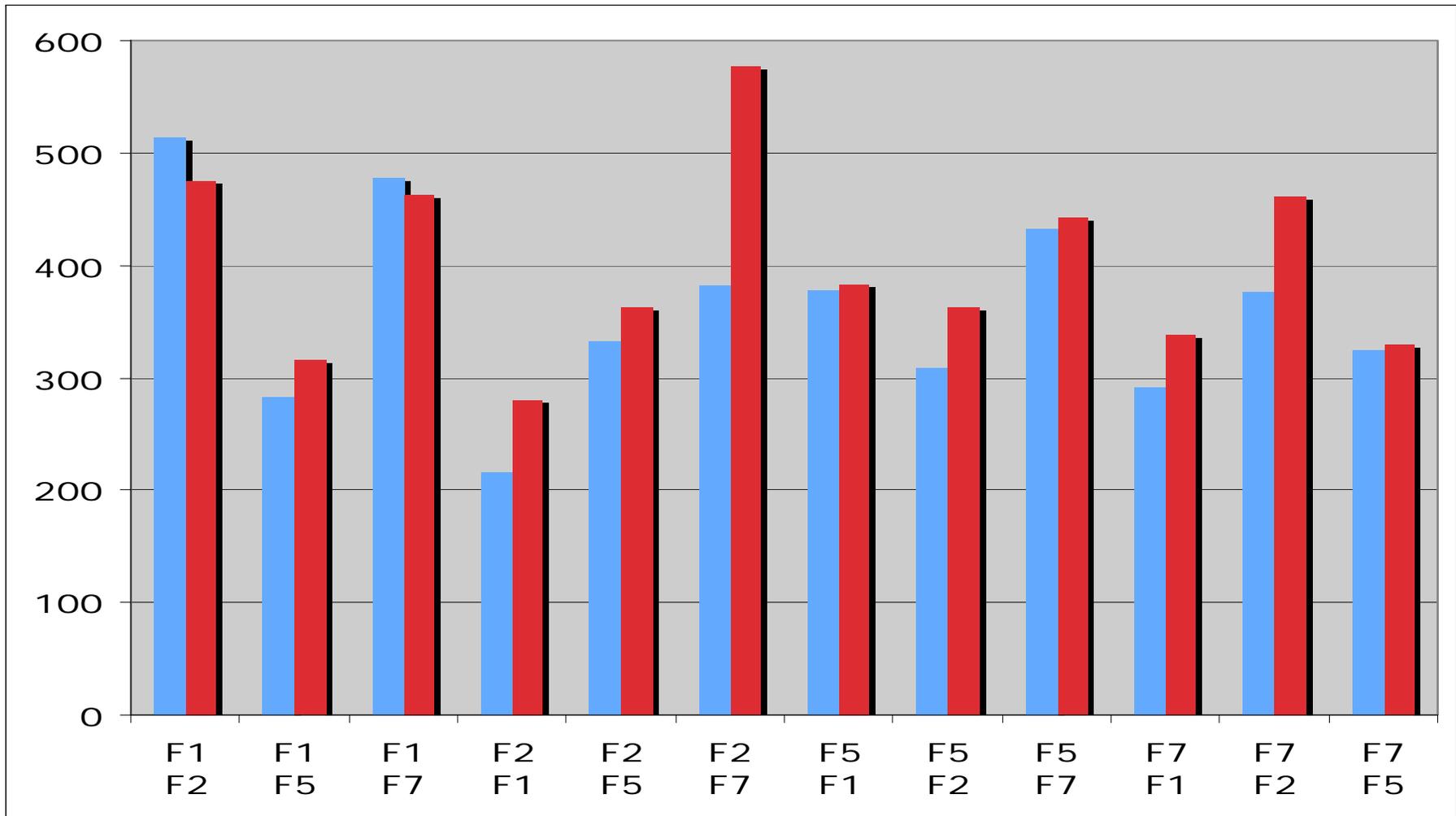
ussishki@u.arizona.edu

Related (blue) vs. Unrelated (red) by binyan pairs: Exp 1a (supraliminal primes)



Related (blue) vs. Unrelated (red) by binyan pairs: Exp 2a (subliminal primes)

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Materials, fillers, and lexical (in)congruency

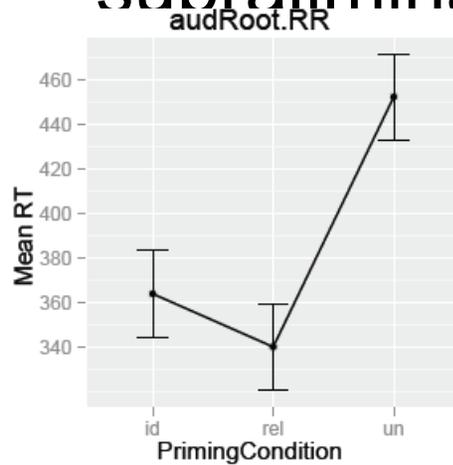
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-
- Congruent pairs
- In all experiments, subjects responded to 36 real word prime-real word target pairs, balanced evenly across the three priming conditions.
 - An equivalent number of nonword prime-nonword target pairs (36) were also included, also balanced evenly across the three priming conditions.
- Incongruent pairs
- An equivalent number of nonword prime-real word target pairs (36) and real word prime-nonword target pairs (36) were also included.

Real word results

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supraliminal



subliminal

