Guideline for Sudanese Colloquial Arabic problem set

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March 15, 2016

1 Brief note on the problem

The idea of this problem set has to do with the notion of inventories and contrast. SCA has a certain preference for CV combinations, so many words which have been adapted from Standard Arabic tend to have some vowel epenthesized, breaking up a CC cluster; however, you can easily find instances of CC if you go beyond the monomorphemic word. Doing so, we see that there's a process of neutralization in voicing and, with the right conditions, manner contrast in the first consonant of a CC cluster. This process is straightforwardly predictable from the quality of the segments, and for this reason it offers us a fun opportunity to shift the focus of the analysis. It's easy for us to think of segments/phonemes as predetermined bundles of acoustic and articulatory information, but I want this data set to challenge this notion. I want the student to try to figure out which contrasts are important for the phonology.

What I aim to do is have the student use the data to arrive at an inventory with the relevant contrasts; in doing so, they will have to perform a phonological analysis, where they will find voicing and manner assimilation operative. The suggested analysis below will cover this, but it will also be tedious. The student is not expected to come up with exactly this analysis — e,g. the use of sets and performing operations on sets — but I do think that ultimately the data leads the student to carry out a similar thought process. Some steps in their analysis may be conflated, which is acceptable. The overarching goal is for the student to be think about what the data suggests the phonology cares about, not what a presupposed theory says it cares about.

2 Arriving at an inventory

The data seen come one of three phrasal constructions, where you have two consonants occurring adjacent to each other:

(1) kitaap taarix — MODIFIED NPs
'history book'

(2) kitaap sami — GENITIVE CONSTRUCTION
'Sami's book'

(3) ʃeeɣ baka — INTRANSITIVE S
'A sheik cired'

There are twelve paradigms of interest: those with *kitaab, d͡ʒawaaz, ʃeex, sawwaag, bit, balad, walad, burud͡ʒ, dˤeef, mudarris, samak,* and *mablaɣ*. Students should be able to organize it in the following way, based on what's happening at the CC cluster. Upon seeing the data, they don't (shouldn't) know what the underlying word-final consonant is; that's why there are slashes in the table.

(4)

total voicing assimilation	partial voicing assimilation	voice and manner assimilation
d͡ʒawaaz/s	dˤeef/v	bit/d/d͡ʒ/s/z/ʃ
burud͡ʒ/t͡ʃ	mudarris/z	balat/d/s/ʃ/d͡ʒ/z
walad/t	ʃeex/ɣ	sawwaak/g/ɣ/x
mablaɣ/x		kitaab/p/f
		samak/g/x

The table suggests that we have two instances of a general phenomenon: assimilation. We see something related to voicing going on with every form, but sometimes we don't see voicing where we expect it (partial voicing) and other times we see a little bit more than voicing assimilation (manner assimilation). Since voicing is the common factor of both phenomena, we'll start there.

2.1 Voicing assimilation

In the instances of a CC cluster, it's the first consonant that changes in quality, so we'll start by listing each consonant that serves as a C_1 and making a list of consonants which follow it. If we just consider CC clusters ordered pairs of consonants $\langle a, b\rangle$, where $a = C_1$ and $b = C_2$, the sets consonants we are looking for is one where each element has the property of being the second member of the ordered pair $\langle a, b\rangle$ for a particular $C_1 = a$, these are in (7).

(5) $\{\langle a, b\rangle : a$ is C_1 and b is C_2 of a CC cluster$\}$

(6) $\{b : b$ occurs in $\langle a, b\rangle$ when $a =$ p$\}\ldots$ for every a

(7)

$a =$ p	{t, s, ʃ, k, x, ħ, h}
b	{d͡ʒ, g, l, m, w, n}
s	{t, ʃ, k, x, ħ, h, l, n, w, r}
z	{b, d, z, d͡ʒ, g, ɣ, ʕ, l, m, w}
t	{t, f, x, h, k, l, m, w}
d	{b, d, d͡ʒ, g, ɣ, ʕ, l, m, w, r}
ɣ	{b, d, z, d͡ʒ, g, ɣ, ʕ, r, w}
x	{f, t, s, ʃ, k, ħ, h, l, n, w, r}
k	{f, s, ʃ, ħ, l, m, w}
g	{b, d, z, d͡ʒ, g, ɣ, ʕ, l, m, w, r}
t͡ʃ	{t, s, k, x, ħ, h}
d͡ʒ	{g, l, m, w}
f	{t, k, l, m, w, r}
v	{b, d, g}

Here we can start to see a pattern emerge. Within every set, every element seems to be related to voicing, except those sets with voiceless consonants and l, r, m, n or w. So, let's first see which C_1 segments can have one of the elements [l, r, m, n, w] follow it, shown in (8), and then let's subtract every one of those elements from each of the sets. The resulting sets without [l, r, m, n, w] are in (10).

(8) $\{a :$ in $\langle a, b\rangle$, $b =$ l, r, m, n, or w$\} = \{$b, f, t, d, s, z, d͡ʒ, k, g, x, ɣ$\}$

(9) $\{b : b$ occurs in $\langle a, b\rangle$ when $a =$ p$\} - \{$l, r, m, n, w$\}\ldots$ for every a

(10)

$a =$ p	{t, s, ʃ, k, x, ħ, h}
b	{d͡ʒ, g}
s	{t, ʃ, k, x, ħ, h}
z	{b, d, z, d͡ʒ, g, ɣ, ʕ}
t	{t, f, x, h, k}
d	{b, d, d͡ʒ, g, ɣ, ʕ}
ɣ	{b, d, z, d͡ʒ, g, ɣ, ʕ}
x	{f, t, s, ʃ, k, ħ, h}
k	{f, s, ʃ, ħ}
g	{b, d, z, d͡ʒ, g, ɣ, ʕ}
t͡ʃ	{t, s, k, x, ħ, h}
d͡ʒ	{g}
f	{t, k}
v	{b, d, g}

Now we can see the relationship between the elements (C_1 segments which can follow a C_1, where $C_1 = a$ of $\langle a, b\rangle$) in each set in (10): the elements share the articulatory and acoustic property of voicing. Next, to see which C_1 elements are related with respect to the consonants which can follow it, we'll take each set in (10) and take the intersection with the other sets. If the intersection between a pair of sets where $C_1 = a_i$ and $C_1 = a_j$ is non-empty, we'll toss it into this new set, as this indicates that they have at least one C_2 in common. To get the set we actually want, we'll take the union of each set of pairs within the larger sets in (11); this gives us a set of these C_1 segments that pattern alike with their C_1 segments.

(11) $A = \{\{a_i, a_j\} : a_i \cap a_j \neq \varnothing\} = \{\{\text{p, s}\}, \{\text{p, t}\}, \{\text{p, x}\}, \{\text{p, k}\}, \{\text{p, t͡ʃ}\}, \{\text{p, f}\}, \{\text{s, t}\}, \ldots \{\text{t͡ʃ, f}\}\}$
$B = \{\{a_i, a_j\} : a_i \cap a_j \neq \varnothing\} = \{\{\text{b, z}\}, \{\text{b, d}\}, \{\text{b, ɣ}\}, \{\text{b, g}\}, \{\text{b, d͡ʒ}\}, \{\text{b, v}\}, \{\text{z, z}\}, \ldots \{\text{d͡ʒ, v}\}\}$

(12) $\bigcup A = \{\text{p, s, t, x, k, t͡ʃ, f}\}$
$\bigcup B = \{\text{b, z, d, ɣ, g, d͡ʒ, v}\}$

The first set of (12) shows consonants that can appear before a $C_2 =$ t, f, s, ʃ, t͡ʃ, x, ħ, or h, and the second shows consonants that can appear before a $C_2 =$ b, v, d, z, d͡ʒ, g, ɣ, or ʕ. We see an obvious connection with respect to voicing between the sets of C_1 segments that pattern alike and the set of C_1 segments with which they occur, and now we can make explicit this intuition. First, we collect the consonants that can be a C_2 when $C_1 \in \bigcup A$, and likewise for the C_2 that have a $C_1 \in \bigcup B$.

(13) $\{b : b \text{ is a member of } \langle a, b\rangle, \text{ when } a \in \bigcup A\} = \{\text{p, s, t, x, k, t͡ʃ, f, ʃ, h, ħ}\}$
$\{b : b \text{ is a member of } \langle a, b\rangle, \text{ when } a \in \bigcup B\} = \{\text{b, d, z, d͡ʒ, g, ɣ, ʕ, v}\}$

Then, we can take the union of the first set in (13) and the first set in (12), which gives us sets of elements that can occur in CC cluster, and those sets have exactly those elements we think are related in an important way. We can do the same for the second set of (12) and (13). In (14) we have two complementary sets constructed from the data, and all of the elements of each set intuitively share the property we observed earlier: voicing. Let's posit a feature α that gets at the contrast between these two sets; we intuit that α represents voicing quality.

(14) $\{\text{p, s, t, x, k, t͡ʃ, f}\} \cup \{\text{p, s, t, x, k, t͡ʃ, f, ʃ, h, ħ}\} = \{\text{p, s, t, x, k, t͡ʃ, f, ʃ, h, ħ}\}$
$\{\text{b, z, d, ɣ, g, d͡ʒ, v}\} \cup \{\text{b, d, z, d͡ʒ, g, ɣ, ʕ, v}\} = \{\text{b, d, z, d͡ʒ, g, ɣ, ʕ, v}\}$

(15) $-\alpha = \{\text{p, s, t, x, k, t͡ʃ, f, ʃ, h, ħ}\}$
$+\alpha = \{\text{b, d, z, d͡ʒ, g, ɣ, ʕ, v}\}$

Now, we must go back to those places where there was a CC cluster and C_2 was among {l, r, m, n, w}. The set of consonants which could surface as a C_1 with a C_2 among {l, r, m, n, w} were shown in (8), repeated in (16). On the surface, these C_2 segments pose a problem; we have gone through the work to say that only CC with the same α feature value that relates each C in a CC, but {l, r, m, n, w} are all acoustically/articulatory voiced consonants, and the data shows that they allow consonants of $\pm\alpha$. One option to remedy this would to go back and not subtract {l, r, m, n, w} out of the other sets, and then try again to factor out classes of consonants which are important with respect to the phonology; however, this won't allow us to arrive at a voice/voiceless contrast because the crucial step which got us to this contrast was constructing a set where the intersection of C_1 segments that could follow a particular C_1 was non-empty. We won't pursue this option. What we can do is consider whether voicing is relevant for {l, r, m, n, w}. If we posit that it isn't, the data simplifies, and we get even further insight. Before considering this possibility, we didn't know the underlying forms for each morpheme, but by positing {l, r, m, n, w} don't play into the voicing alternation we see, we can hypothesize that the forms which occur with a C_2 among {l, r, m, n, w} show us the underlying word-final consonant. This turns out to be the case. Consequently, we find that {v, ʃ, p, t͡ʃ} are allophones in the data, since they don't occur among the set of C_1 which can occur with {l, r, m, n, w} as C_2. This is shown in (17); we take the union of the sets of consonants (voice/voiceless) which can occur as C_1 and subtract the ones that can occur with {l, r, m, n, w}, those C_1 segments we posit are underlying.

(16) $\{a : \text{in } \langle a, b\rangle,\ b = \text{l, r, m, n, or w}\} = \{\text{b, f, t, d, s, z, d͡ʒ, k, g, x, ɣ}\}$

(17) $\{\{p, s, t, x, k, \widehat{t\int}, f, \int, h, ħ\} \cup \{b, d, z, \widehat{d\text{ʒ}}, g, ɣ, ʕ, v\}\} - \{b, f, t, d, s, z, \widehat{d\text{ʒ}}, k, g, x, ɣ\} = \{p, v, \int, \widehat{t\int}\}$

Having made the assumption that is voicing not relevant for the contrast in {l, r, m, n, w}, we can go back through each paradigm and state the underlying forms for the morphemes of interest.

(18)

	UR	
	kitaab	'book'
	$\widehat{d\text{ʒ}}$awaaz	'passport'
	∫eex	'sheik'
	sawwaag	'driver'
	bit	'girl'
	balad	'country'
	walad	'boy'
	burud$\widehat{\text{ʒ}}$	'tower'
	d^{ʕ}eef	'guest'
	mudarris	'teacher'
	samak	'fish'
	mablaɣ	'amount'

The partial vs. total voicing assimilation problem has been reduced to a single phenomenon, so let's propose an analysis for the CC clusters. We found that we have CC clusters with the same voicing feature α, but only if they have a feature α; we can write a simple assimilation rule to capture this behavior.

(19) $C\left[\pm voice\right] \rightarrow C\left[\alpha_{voice}\right] \Big/ \underline{\quad} C\left[\alpha_{voice}\right]$ VOICING ASSIMILATION

This accounts for the alternation in the forms *$\widehat{d\text{ʒ}}$awaaz, burud$\widehat{\text{ʒ}}$, walad, mablaɣ, ∫eex, d^{ʕ}eef* and *mudarris*, and we have the working inventory.

(20) $-\alpha = \{p, s, t, x, k, \widehat{t\int}, f, \int, h, ħ\}$
$+\alpha = \{b, d, z, \widehat{d\text{ʒ}}, g, ɣ, ʕ, v\}$
α n/a = {l, r, m, n, w}

2.2 Assimilation/lenition

Left to account for are the following forms, which have something beyond voicing assimilation happening: *bit, balad, sawwaag, samak*, and *kitaab*. We now have the underlying forms for these morphemes, giving us a more informed starting point start than before. The first thing we will do is try to see which consonants underlyingly can undergo this alternation. To do this, we make a set of all the consonants which are underlyingly a C_1 of a CC, but then become C_1' such that $C_1' = C_2$.

(21) $\{a : a \text{ in } \langle a, b\rangle \text{ undergoes alternation}\} = \{b, t, d, k, g\}$
$\{a : a \text{ in } \langle a, b\rangle \text{ doesn't undergo alternation}\} = \{f, s, z, \widehat{d\text{ʒ}}, d, ɣ, x\}$

Since we've again constructed complementary sets, we would like a feature that codify this fact. Intuitively, the first set has the property of being articulated as (oral) stops; the second set contains which aren't stops. We'll posit the feature β such that it represents this fact, and each set will differ with respect to its value.

(22) $+\beta = \{b, t, d, k, g\}$
$-\beta = \{f, s, z, \widehat{d\text{ʒ}}, d, ɣ, x\}$

We just established a pre-condition for a consonant to undergo this process: it must be a stop. Before checking where we're at with our inventory, we should figure out in what context this change in manner occurs, as it may tell us more information. Analogous to what we did before, we'll take each consonant that can occur as a C_1 in a CC where this process occurs, and we'll construct a set around that consonant such that the set will have all the C_1 segments which can trigger that C_1 to become C_1', where $C_1' = C_2$.

(23) $\{b : b \text{ in } \langle a, b\rangle \text{ where } a' = b\}$, for every a with $[+\beta]$

(24)

$a =$	
b	{f}
t	{s, z, ʃ, d͡ʒ, d}
d	{s, z, ʃ, d͡ʒ, t}
k	{g, x, ɣ}
g	{k, x, ɣ}

The sets in (24) are striking. Immediately, we can note that there's a three-way contrast which intuitively resembles a place contrast. Another thing we see is the elements in these sets are non-stops, except for a few pesky elements; however, note that these are precisely the alternations we can explain with our voicing assimilation rule. They were accidentally caught by our defining property for the sets in (24). Since these are already explained, let's subtract the stops (feature $[+\beta]$) {t, d, k, g} out of the relevant sets, giving us the sets in (25).

(25)

$a =$	
b	{f}
t	{s, z, ʃ, d͡ʒ}
d	{s, z, ʃ, d͡ʒ}
k	{x, ɣ}
g	{x, ɣ}

To make explicit the second observation we made — the observation that the C_1 segments are non-stops — we'll take the union of all the sets in (25). Another observation we made pertained to the three-way contrast that we suspect has to do with place of articulation. We'll capture this insight by taking the pairs of C_1 segments, $\{a_i, a_j\}$, and make a set with all those pairs which have a non-empty intersection, seen in (27). Finally, in (28) we take the union of these sets in (27) to give us a set with the C_1 segments that show this three-way contrast.

(26) $\bigcup\{b : b \text{ in } \langle a, b\rangle \text{ where } a' = b\} = \{\text{f, s, z, ʃ, d͡ʒ, x, ɣ}\}$ CONTEXT FOR MANNER CHANGE

(27) $L = \{\{a_i, a_j\} : a_i \cap a_j \neq \varnothing\} = \{\{\text{b, b}\}\}$
$C = \{\{a_i, a_j\} : a_i \cap a_j \neq \varnothing\} = \{\{\text{t, t}\}, \{\text{t, d}\}, \{\text{d, d}\}\}$
$D = \{\{a_i, a_j\} : a_i \cap a_j \neq \varnothing\} = \{\{\text{k, k}\}, \{\text{k, g}\}, \{\text{g, g}\}\}$

(28) $\bigcup L = \{\text{b}\}$
$\bigcup C = \{\text{t, d}\}$
$\bigcup D = \{\text{k, g}\}$

Now, we can these put C_1 segments which pattern together with the corresponding C_2 segments that induce this assimilation. That will give us the following sets, each of which we can think of intuitively as sharing a feature that represents place of articulation. We'll call that feature γ, and each of these sets will differ on γ, having the names labial, coronal, and dorsal respectively.

(29) $\bigcup L \cup \{b : b \text{ in } \langle a, b\rangle \text{ where } a' = b, \text{ and } a \in \bigcup L\} = \{\text{b, f}\}$ LABIAL
$\bigcup C \cup \{b : b \text{ in } \langle a, b\rangle \text{ where } a' = b, \text{ and } a \in \bigcup C\} = \{\text{t, d, s, z, ʃ, d͡ʒ}\}$ CORONAL
$\bigcup D \cup \{b : b \text{ in } \langle a, b\rangle \text{ where } a' = b, \text{ and } a \in \bigcup D\} = \{\text{k, g, x, ɣ}\}$ DORSAL

The sets in (29) have what we wanted in the first place; they have elements that we thought shared the same place of articulation, driving the manner assimilation process. Additionally, we note that we now have the relevant pieces to posit another rule, which we will call 'manner assimilation'.

(30) $C\begin{bmatrix} stop \\ \gamma_{place} \end{bmatrix} \rightarrow C\,[non-stop] \,/\, \_\_\_\_ C\begin{bmatrix} non-stop \\ \gamma_{place} \end{bmatrix}$ MANNER ASSIMILATION

2.3 Taking inventory

We have following rules and the following inventory. Note that we can split the inventory up into pairs of segments that differ by at least one feature, except for the coronals that are non-stops. Also, note that we don't have enough information as to what [l, r, m, n, w] are, but we do know that they aren't what stops or non-stops under our definition because they don't play a role in the manner assimilation process (where β drives the process).

(31) $C\left[\pm voice\right] \rightarrow C\left[\alpha_{voice}\right] \Big/ \_\_\_\_ C\left[\alpha_{voice}\right]$ VOICING ASSIMILATION

(32) $C\begin{bmatrix} stop \\ \gamma_{place} \end{bmatrix} \rightarrow C\left[non-stop\right] \Big/ \_\_\_\_ C\begin{bmatrix} non-stop \\ \gamma_{place} \end{bmatrix}$ MANNER ASSIMILATION

(33)

	α	β	γ
b	+voice	stop	labial
f	-voice	non-stop	labial
t	-voice	stop	coronal
d	+voice	stop	coronal
s	-voice	non-stop	coronal
ʃ	-voice	non-stop	coronal
z	+voice	non-stop	coronal
d͡ʒ	+voice	non-stop	coronal
k	-voice	stop	back
g	+voice	stop	back
x	-voice	non-stop	back
ɣ	+voice	non-stop	back
m	n/a	—	—
n	n/a	—	—
r	n/a	—	—
l	n/a	—	—
w	n/a	—	—

This answer will suffice for the first part of the problem, as long as they note which consonants don't have unique characterizations. Again, I don't expect the student to go through each step that I went through, but the reasoning should more or less be the same. The student can also use a couple additional pieces of data to move towards resolving this ambiguity in the coronal non-stops. The following data from the manner assimilation suggest a difference in these non-stop coronals, and the student can posit another feature δ (name doesn't matter), which accounts for this difference, and then they can build that feature into their rule for manner assimilation

(34)

balaʃ ʃaaf	'a country saw'
balas samħa	'a beautiful country'
bid͡ʒ d͡ʒamila	'a beautiful girl'
biz zakiyya	'an intelligent girl'

(35)

	α	β	γ	δ
s	-voice	non-stop	coronal	$-\delta$
ʃ	-voice	non-stop	coronal	$+\delta$
z	+voice	non-stop	coronal	$-\delta$
d͡ʒ	+voice	non-stop	coronal	$+\delta$

(36) $C\begin{bmatrix} stop \\ \gamma_{place} \end{bmatrix} \rightarrow C\begin{bmatrix} non-stop \\ \delta \end{bmatrix} \Big/ \_\_\_\_ C\begin{bmatrix} non-stop \\ \gamma_{place} \\ \delta \end{bmatrix}$ MANNER ASSIMILATION

3 Accounting for the pharyngeals

The second part of this problem introduces data when the first word ends with the consonant [ħ], and it doesn't fit the generalization earlier with regard to voicing assimilation. The only place we see voicing assimilation in this data is when it *balaħ* is followed by the word *ʕiraaqi*.

(37) balaʕ ʕiraaqi 'Iraqi dates'

This data suggests that there is one more condition that needs to be met for the voicing assimilation rule to apply, which we will again codify with a feature that distinguishes classes of consonants. The instructions tell the student to assume the same pattern holds for a paradigm where the first word ends in [ʕ], so we can arrive at the following sets of consonants that we will distinguish with the feature ϵ, called 'emphasis'.

(38) {b, f, t, d, s, z, ʃ, d͡ʒ, k, g, x, ɣ} NON-EMPHATIC
{ħ, ʕ} EMPHTATIC

Now, we can modify our voicing assimilation rule, and we can append [ħ] and [ʕ] to our existing inventory.

(39) $C\begin{bmatrix} \pm voice \\ \epsilon_{emphasis} \end{bmatrix} \rightarrow C\left[\alpha_{voice}\right] \Big/ \_\_\_\_ C\begin{bmatrix} \alpha_{voice} \\ \epsilon_{emphasis} \end{bmatrix}$ VOICING ASSIMILATION

(40)

	α	β	γ	δ	ϵ
b	+voice	stop	labial	—	non-emphatic
f	-voice	non-stop	labial	—	non-emphatic
t	-voice	stop	coronal	—	non-emphatic
d	+voice	stop	coronal	—	non-emphatic
s	-voice	non-stop	coronal	apical	non-emphatic
ʃ	-voice	non-stop	coronal	non-apical	non-emphatic
z	+voice	non-stop	coronal	apical	non-emphatic
d͡ʒ	+voice	non-stop	coronal	non-apical	non-emphatic
k	-voice	stop	back	—	non-emphatic
g	+voice	stop	back	—	non-emphatic
x	-voice	non-stop	back	—	non-emphatic
ɣ	+voice	non-stop	back	—	non-emphatic
ħ	-voice	non-stop	—	—	emphatic
ʕ	+voice	non-stop	—	—	emphatic
m	n/a	—	—	—	—
n	n/a	—	—	—	—
r	n/a	—	—	—	—
l	n/a	—	—	—	—
w	n/a	—	—	—	—

4 Optional part

The question of whether or not we can maintain this analysis is no. What's going on here is that we have an alternation with the [l] of the *ʔal* paradigm, but we don't see the same thing occurring in the noun and verb inflectional paradigms. Descriptively, the [l] completely assimilates to the following consonant in the *ʔal* paradigm if it is a coronal; however, we don't have the all the relevant consonants covered with our current

inventory and the features we have to make that observation explicit. We would have to revamp our analysis and use this data as evidence to suggest that [l, r, n] are coronal while [m, w] aren't. In the other paradigms, we see consonant clusters with [l], but we don't see it assimilating, even if the sounds are coronal. There are three salient options at this point: 1) our current analysis is off track; 2) this is a morphological alternation with *ʔal*; or 3) this phonological process is sensitive to the boundary type. The second and third options, in my opinion, are potentially interesting ones. If option three were the case, the process would be sensitive only to word boundaries, not just morpheme boundaries. There isn't the data to adjudicate one way or the other at this point.