The Utility of Manual and Automatic Linguistic Error Codes for Identifying Neurodevelopmental Disorders

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Overview

- Clinical background and limitations
- Systematic Analysis of Language Transcripts
  - (SALT)
- Our investigation

Clinical Groups

- Autism
  - Impaired social interaction
  - Impairments in communication
  - Restricted repetitive and stereotyped behavior
- Language Impairment
  - Difficulty acquiring morphology/syntax
    - Ex: He go to the store.
  - Diagnosed with standardized test (CELF)

Clinical Groups

	Impaired Language	Unimpaired Language
Autism	**ALI**	**ALN**
No Autism	**SLI**	**TD**

Clinical Groups

Impaired Language	Unimpaired Language
LI	**LN**

Clinical Groups

Autism	**ASD**
No Autism	**nASD**

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SALT Steps

- Transcribe
- Code
- Software

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Basic Transcript

- They he's using he's holding the remote and using his tongue to press the buttons.
- I goed out in the sky.
- A good friend means like in hameh kleem.

SALT Steps

- Transcribe
- Code
- Software

Coding steps

- Identify edits (mazes)
- Separate certain bound morphemes/clitics
- Add error codes

Example 1

- He going now.

Example 1

- He go/ING now.

Example 1

- He [OW] go/ING now.

Example 2

- And they like and she like faints.

Example 2

- (And they like) and she (like) faints.

Example 2

- (And they like) and she (like) faint/3S.

Error Codes

- EC: Inappropriate response
  Did you help yourself stop? **Mom[EC]**.
- EO: Overgeneralization
  Yeah, cuz I almost saw/ED[EO] one.
- EU: Utterance-level error
  You can see it very hard because it/'S under my hair. [EU]
- EX: extraneous word
  Would you like to be[EX] fall down?
- OM: omitted morpheme
  The cat eat[OM] fish.
- OW: omitted word
  He [OW] going now.

Error Words

- I play/ED of[EW] the cat.
- Mmhmm, I was very disappointing[EW]
- There was[EW] these other kids.
- A[EW] elephant.
- Sometimes I five[EW] something to do.
- It is his favoritest[EW] game.
- …we might have got[EW] some candy there…
- She got/3S[EW] fifteen.
- He go/ED/ED[EW].
- …it come[EW] right back here.
- He[EW] always listen/3s to (Steve) <Steven>.

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Key Questions

- Are SALT-derived features of diagnostic utility? If so, which ones?
  - How about in the face of comorbid disorders?
- If we were to automate, how good a job must we do?
- Can we automate their detection?

Data

- 144 ADOS transcripts with SALT annotations
- Kids ages 4-8
- MLU >= 3
- IQ > 70

Matched Groups

Group 1		**Group 2**		
Diagnosis	N	Diagnosis	N	Matched
ALI	25	ALN	21	Age, ADOS, SCQ
ALI	24	SLI	19	Age, NVIQ, VIQ
ALN	25	TD	27	Age, NVIQ, VIQ
ASD	48	nASD	61	Age
LN	61	LI	39	Age
SLI	15	TD	38	Age

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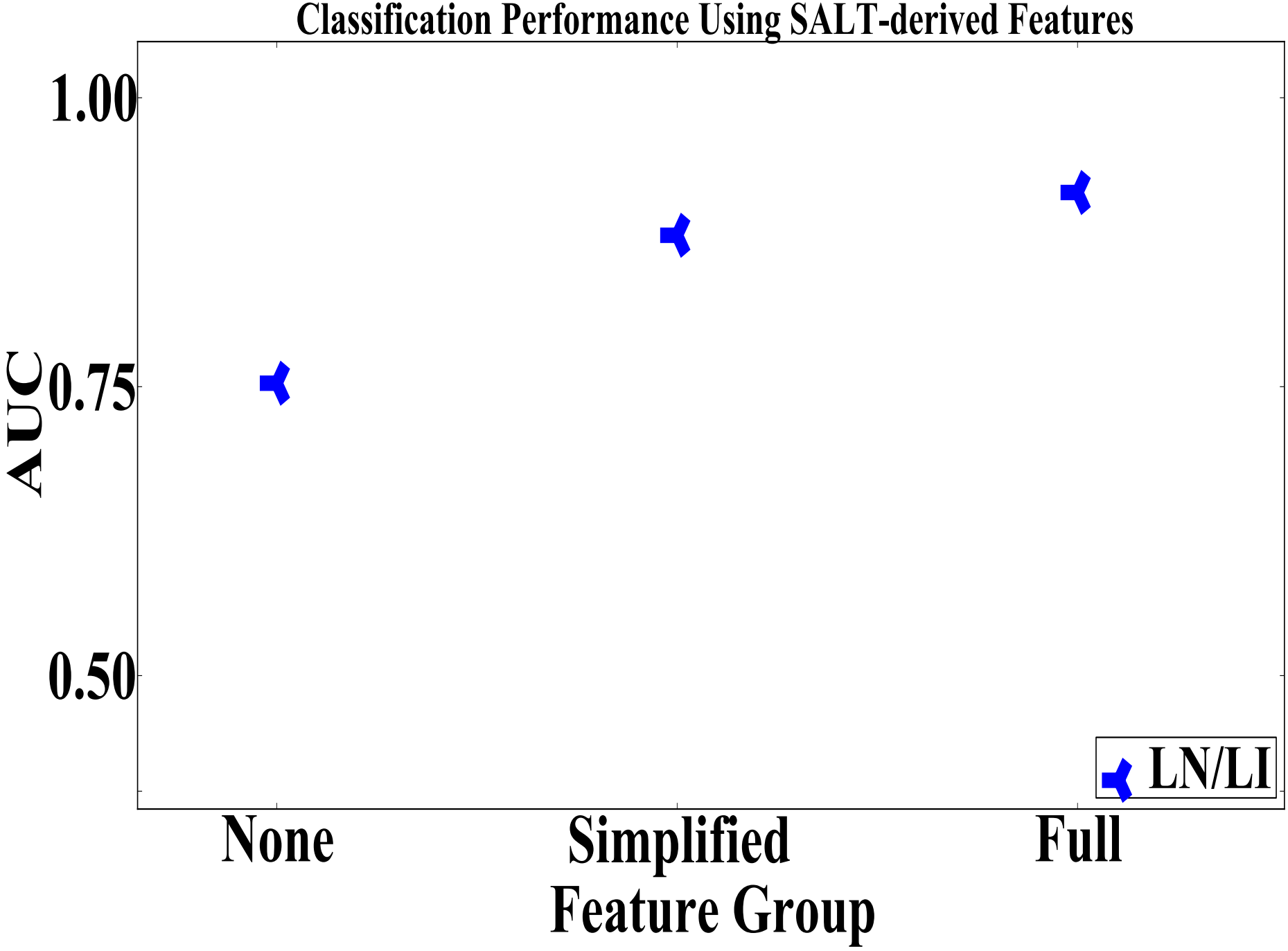
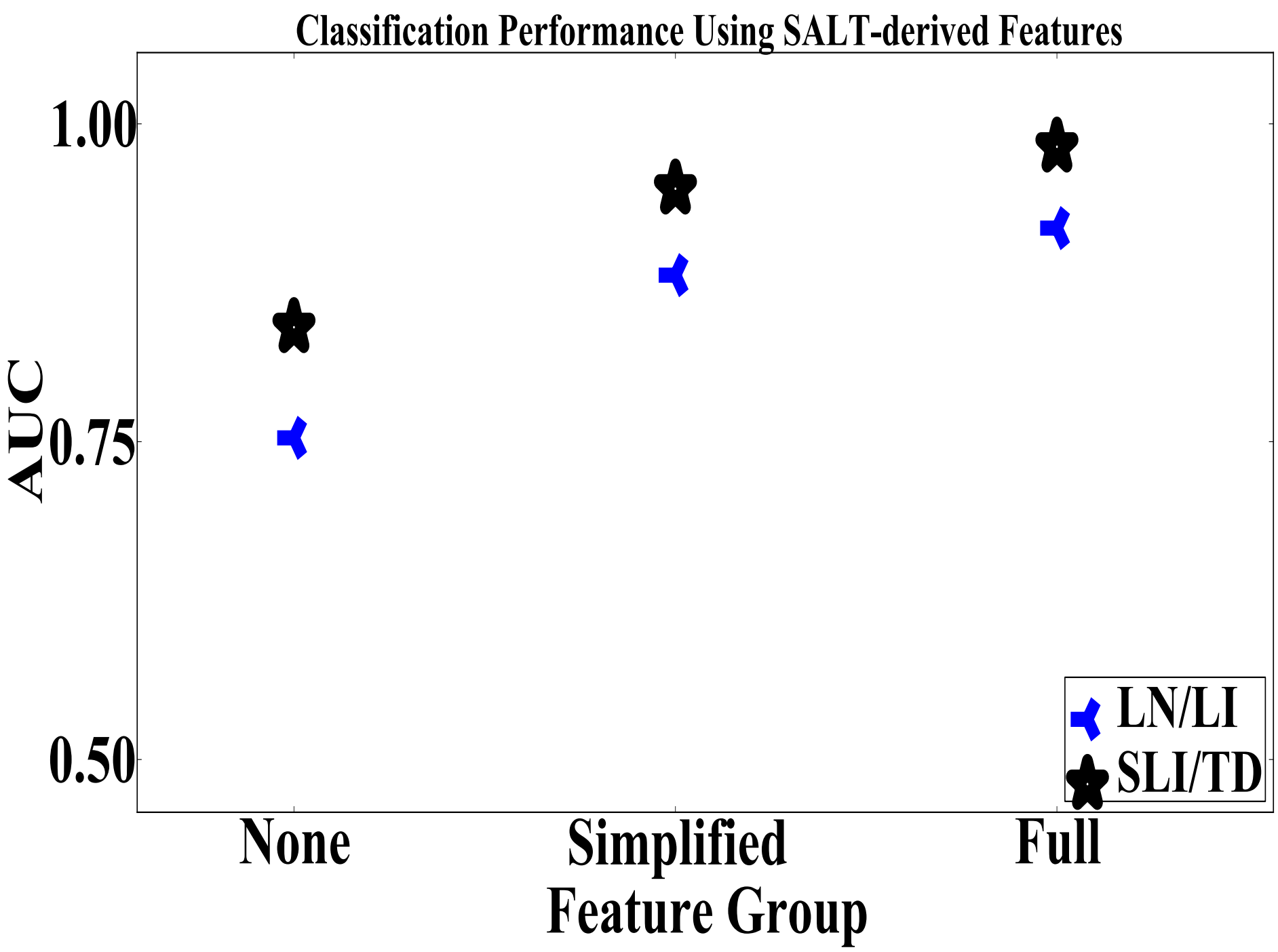
Diagnostic classification task

- Take matched pair
- Get features for each child
- Do leave-pair out classification
- Unbiased estimate of area under receiver operating characteristic curve (AUC) (Airola et al, 2011)

Feature Sets

- **None**: can be derived from transcript
- **Basic**: # utterances with errors; maze/ morpheme boundaries
- **Full**: individual error code counts


Classification Performance Using SALT-derived Features
1.00
0.75
0.50
AUC
None
Simplified
Full
Feature Group
LN/LI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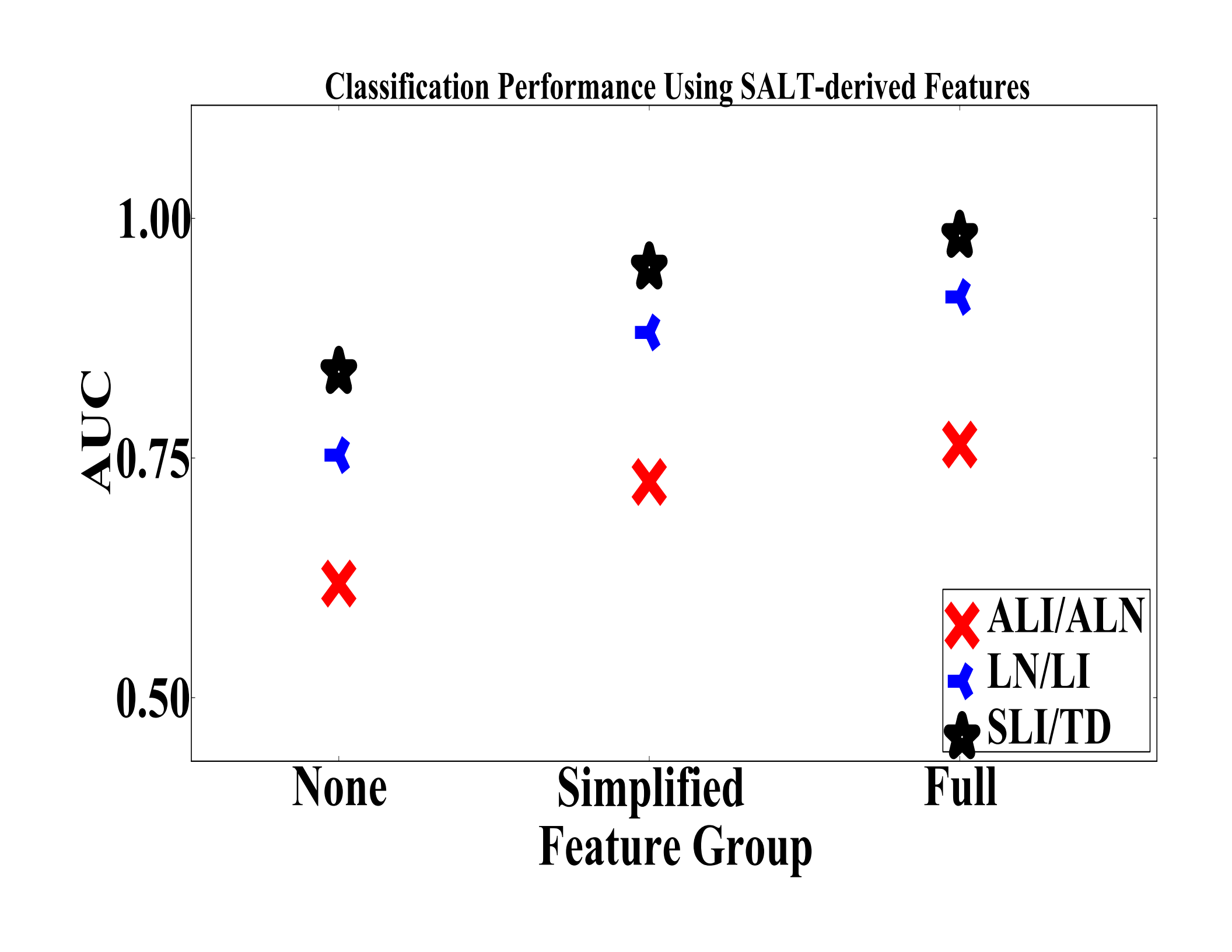
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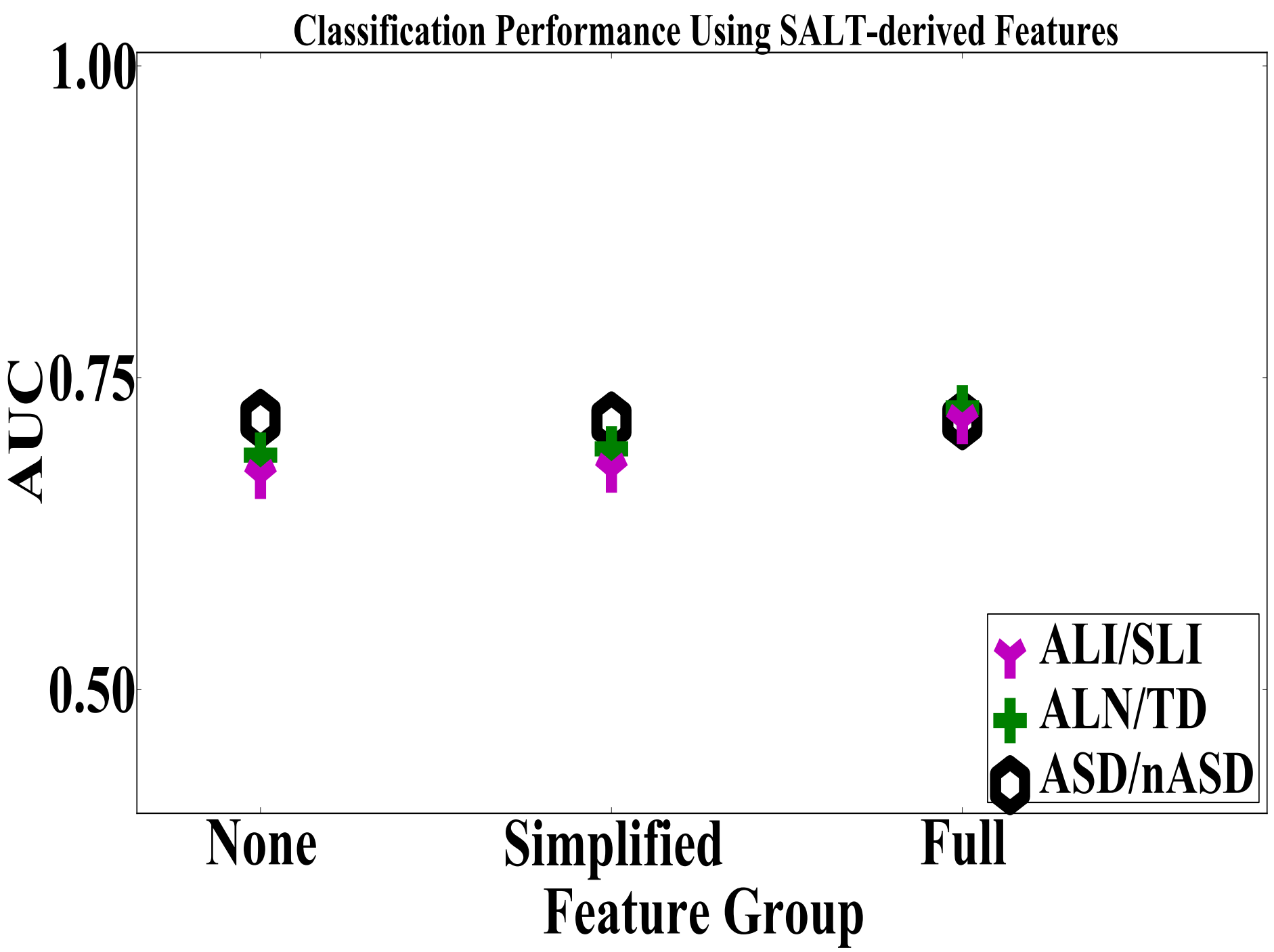
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ALN/TD
ASD/nASD

Detecting Particular Errors

Dx Pair	Errors	AUC	% Max
ALI/ALN	EW, OM	.762	100
	EW, OM, OW	.739	97
	all	.724	93
LN/LI	EW, OM, OW	.901	100
	all	.881	98
SLI/TD	OM, OW	.984	100
	EW, OM, OW	.970	99
	all	.951	97

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Mapping of Detectors to Tags

Error	Tag
Misuse of –ing participle	EW
Missing copulae	OW
Missing verb	OW
Subject-aux agreement	EW
Subject-verb agreement	EW/OM
Missing infinitive ‘to’	OW

Automatic Error Detection – H&L

Codes Detected	P	R	F1
EW	0.074	0.218	0.110
EW, OM	0.049	0.277	0.083
OM, OW	0.028	0.191	0.049
All three	0.066	0.354	0.111

Automatic Error Detection – POS Tags

Codes Detected	P	R	F1
EW	.074	.218	.110
OM	.070	.191	.103
OW	.064	.210	.099
EW/OM	.102	.269	.148
OM/OW	.102	.269	.148
All three	.127	.308	.180

Diagnostic Classification Accuracy

Diagnostic Pair	Baseline
ALI/ALN	.619
LN/LI	.755
SLI/TD	.840

Diagnostic Classification Accuracy

Diagnostic Pair	Baseline	+SALT
		Manual
ALI/ALN	.619	.723
LN/LI	.755	.881
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Diagnostic Classification Accuracy

Diagnostic Pair	Baseline	+SALT	
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Diagnostic Classification Accuracy

Diagnostic Pair	**Baseline**	**+SALT**		
		Manual	Auto	+Optimized θ
ALI/ALN	.619	.723	.611	**.676**
LN/LI	.755	.881	.801	**.801**
SLI/TD	.840	.951	.805	.840

Future Work

- Error subtypes
  - Greatly improved error detection
  - Error subtypes are of diagnostic utility
- How good are humans at using SALT?
- Automatic maze/edit detection

Baseline Features

- # of times examiner speaks while child is talking
- # of times child speaks while examiner is talking
- Incomplete word count
- Ratio of open- to closed-class words
- Token count
- Type count
- Ratio of ‘uh’ to ‘um’
- Unintelligible word count

SALT-1 Features

- Morpheme count
- Edit count

SALT-2 Feature

- Number of utterances with any SALT error codes

SALT-3 Feature

- Count of SALT error codes

SALT-4 Features

- Count of utterance level errors (EC/EU)
- Count of word level errors (all others)

SALT-5 Features

- Count of each error code