Western
National Centre
for Audiology

DSL® v5 by Hand

Desired Sensation Level (DSL) Method
The general rationale of the DSL method is to use a systematic procedure to provide hearing impaired individuals with an amplified speech signal that is audible, comfortable and undistorted across the broadest relevant frequency range possible. This method takes into account age appropriate ear canal values, either by using measurements, or by predicting them based on age. Specifically, external ear resonance characteristics and real-ear to 2cc coupler differences (RECD). DSL v5 is usually used within commercially available software systems. A software utility is also available for research. The purpose of this "by hand" version is to illustrate the key features of DSL v5. It produces hearing aid prescriptions that are highly similar to those in software-assisted implementations, but omits some details of implementation. Key differences are outlined in Appendix 1.

Step 1: Individualize the Hearing Assessment Data: (Tables 1 and 2)
Because infants may be tested using electrophysiologic threshold estimates, a set of corrections is used to convert frequency-specific ABR thresholds from nHL to eHL. Omit this step if thresholds were gathered behaviourally, or if the infant's electrophysiological data have already been corrected to HL (e.g., manual corrections have been applied, frequency specific ASSR).

Because infants and very young children have ear canals that are very different from those of the average adult, accuracy of the "by hand" targets may be improved if these differences are removed from the HL audiogram before targets are prescribed. This step produces Equivalent Adult HL thresholds for use when looking up targets in Table 2. This is a modification of DSL v5 that allows one set of target tables to be used, and has only been developed in this tool for insert phone audiometry. In software implementations of DSL v5, this is not done, because the targets are derived after thresholds have been converted to real ear SPL. The two methods both account for the child's RECD at assessment. For older children and adults, this step may not have a large effect on the prescription. For those tested with non-insert phones, this by-hand tool does not provide full age correction for assessment data.

Step 2: Select desired targets (in dB SPL in the earl canal) as a function of threshold (dB HL)
The real-ear aided response values, measured in dB, indicate the prescribed levels of aided speech at 55, 65, and 75 dB SPL input levels. The target values shown have used the "Pediatric" targets in DSL v5, and assume a WDRC hearing aid with 17 channels of compression.

Step 3. Convert the real ear SPL targets to the coupler for verification
Either age-appropriate or individually measured Real Ear to Coupler Difference (RECD) values are used, in combination with Microphone Location Effects and the levels of unaided speech to convert the prescription to 2cc coupler gain. This process considers whether the hearing aid will

be verified either in the HA2 coupler (for BTE instruments) or the HA1 coupler (for custom instruments). The hearing aid should be placed on the correct coupler, and fine tuned to the level and shape of the targets.

Western
National Centre
for Audiology

Step 1: Individualize the Hearing Assessment Data: (Tables 1 and 2)

Table 1: **nHL to eHL Transform**

If the infant's hearing was tested with frequency specific ABR, please complete the following table. Otherwise, skip to the next step.

- If thresholds are measured via FS-ABR and correction has not been made previously – calculate estimated hearing level before proceeding to HL to SPL transform
- Enter individual's hearing threshold measures as a function of frequency
- To determine the individual's thresholds across frequencies in dB eHL add the threshold dB nHL to the corresponding correction factor (row 1+2).

	250	500	750	1000	1500	2000	3000	4000	6000
Threshold dB nHL									
Correction Factors	30	20	17	15	12	10	7	5	5
Threshold dB eHL									

Table 2: **Child to Equivalent Adult Hearing Threshold Transform**

If the infant's hearing was tested with insert phones, complete table 2. Otherwise, skip to the next step.

- Enter infant's measured RECD values or age appropriate averages as a function of frequency
- To determine the difference correction subtract the infant RECD from the average adult RECD (these correction assume that a standard tip was used for audiometry).

	250	500	750	1000	1500	2000	3000	4000	6000
Average Adult RECD	3	4	4	6	10	9	11	15	19
Infant RECD (tip, HA1)									
Difference (correction)									

- Enter infant's hearing threshold measures as a function of frequency
- Enter difference correction as a function of frequency from above calculation
- Determine the equivalent adult HL by adding the correction to the infant hearing threshold.

	250	500	750	1000	1500	2000	3000	4000	6000
Infant HL or eHL									
Correction									
Equivalent Adult HL									
Carry this final value over to the following page, line 1 of Table 3									

Step 2: Select desired targets (in dB SPL in the earl canal) as a function of threshold (dB HL) and Step 3. Convert the real ear SPL targets to the coupler for verification

Look up Targets and Convert to Target 2cc Coupler Gain on the Target Worksheet

- Enter individual's hearing level thresholds or equivalent adult hearing level thresholds as a function of frequency.
- Using Tables 6-9), determine the target SPL output as a function of frequency and hearing threshold level for soft, medium, and loud speech. These have been calculated for input levels of 55, 65, and 75 dB SPL. Also look up the target levels for output limiting, which are calculated for a 90 dB SPL narrowband signal.
- Enter the individual's measured RECD values. If measured values cannot be obtained, use estimated age-appropriate RECD values from Table 3 or 4. For BTE hearing aids, use a custom earmold RECD with an HA2 coupler. For custom hearing aids (ITE, ITC, CIC) use a foam tip RECD with an HA 1 coupler.
- Enter the appropriate microphone location effect values as a function of hearing aid style
- To determine the target 2cc coupler gain values across frequencies, subtract the input level, RECD and mic location effect values from the target SPL output (row 2-3-4-5).

Western
National Centre
for Audiology

DSL v5 Target Worksheet:

Soft Speech (55)	250	500	750	1000	1500	2000	3000	4000	6000
Threshold HL/ Equivalent									
Target SPL Output									
Subtract input SPL	[-] 45	47	42	40	38	34	32	31	30
Subtract RECD	[-]								
Subtract Mic Effects	[-]								
Target Coupler Gain									

Mid Speech (65)	250	500	750	1000	1500	2000	3000	4000	6000
Threshold HL/ Equivalent									
Target SPL Output									
Subtract input SPL	[-] 55	57	52	50	48	44	42	41	40
Subtract RECD	[-]								
Subtract Mic Effects	[-]								
Target Coupler Gain									

Loud Speech (75)	250	500	750	1000	1500	2000	3000	4000	6000
Threshold HL/ Equivalent									
Target SPL Output									
Subtract input SPL	[-] 57	65	66	64	65	61	57	56	50
Subtract RECD	[-]								
Subtract Mic Effects	[-]								
Target Coupler Gain									

Max Output (90)	250	500	750	1000	1500	2000	3000	4000	6000
Threshold HL/ Equivalent									
Target SPL Maximum Output									
Subtract RECD	[-]								
Target Coupler OSPL-90									

Western
National Centre
for Audiology

Table 3. Predicted Real-Ear to 2cc Coupler Differences (RECD) by age: Earmolds

Predicted RECDs for Custom Earmolds and an HA1 Coupler

		Frequency (Hz)								
Age (mo)	Age (y)	250	500	750	1000	1500	2000	3000	4000	6000
1		8	12	14	17	20	20	18	19	26
4		6	10	12	15	18	18	16	16	22
7		6	9	11	14	17	18	14	15	20
10		5	9	11	13	16	17	14	14	19
13		5	9	10	13	16	17	13	13	18
16		4	8	10	13	16	16	13	13	17
19		4	8	10	13	16	16	12	12	16
22		4	8	10	12	15	16	12	12	16
25		4	8	10	12	15	16	12	12	16
34		3	7	9	12	15	15	11	11	15
	>3	3	7	9	11	15	15	11	11	14
	4 to 5	3	7	9	11	14	15	10	10	13
	6	3	6	8	10	14	14	10	9	13
Adult	>6	3	5	5	7	11	10	5	5	13

Predicted RECDs for Custom Earmolds and an HA2 Coupler

		Frequency (Hz)								
Age (mo)	Age (y)	250	500	750	1000	1500	2000	3000	4000	6000
1		8	12	13	16	17	17	16	17	21
4		6	10	12	14	15	15	13	14	17
7		6	9	11	13	14	14	12	12	15
10		5	9	10	12	14	13	11	12	13
13		5	9	10	12	13	13	11	11	13
16		4	8	10	12	13	13	10	10	12
19		4	8	10	12	13	12	10	10	11
22		4	8	10	11	13	12	10	10	11
25		4	8	9	11	12	12	9	9	10
34		3	7	9	11	12	12	9	9	9
	>3	3	7	9	10	12	11	9	9	9
	4 to 5	3	7	8	10	11	11	8	8	8
	6	3	6	8	9	11	11	7	7	8
Adult	>6	3	5	5	6	8	6	2	3	8

Western
National Centre
for Audiology

Table 4. Predicted Real-Ear to 2cc Coupler Differences (RECD) by age: Eartips

Predicted RECDs for Eartips and an HA1 Coupler

		Frequency (Hz)								
Age (mo)	Age (y)	250	500	750	1000	1500	2000	3000	4000	6000
1		3	8	10	13	18	19	18	23	28
4		3	7	9	12	15	16	15	20	24
7		3	6	8	11	14	15	14	19	23
10		3	6	8	11	13	15	14	18	22
13		3	6	8	11	13	14	13	17	21
16		3	6	8	11	13	14	13	17	21
19		3	6	8	11	12	14	12	17	20
22		3	5	8	11	12	13	12	16	20
25		3	5	7	10	12	13	12	16	20
34		3	5	7	10	11	13	11	15	19
	>3	3	5	7	10	11	13	11	15	19
	4 to 5	3	5	7	10	10	12	11	15	19
	6	3	5	7	10	10	11	11	15	19
Adult	>6	3	4	4	6	10	9	11	15	19

Predicted RECDs for Eartips and an HA2 Coupler

		Frequency (Hz)								
Age (mo)	Age (y)	250	500	750	1000	1500	2000	3000	4000	6000
1		3	8	9	12	15	15	15	20	23
4		3	7	8	11	12	13	13	18	19
7		3	6	8	10	11	12	12	16	18
10		3	6	8	10	11	11	11	16	17
13		3	6	8	10	10	11	11	15	16
16		3	6	7	10	10	10	10	15	16
19		3	6	7	10	9	10	10	14	15
22		3	5	7	10	9	10	10	14	15
25		3	5	7	9	9	9	9	14	15
34		3	5	7	9	8	9	9	13	14
	>3	3	5	7	9	8	9	9	13	14
	4 to 5	3	5	7	9	7	8	8	13	13
	6	3	5	7	9	7	8	8	13	13
Adult	>6	3	4	4	5	7	5	8	13	13

Western
National Centre
for Audiology

Table 5. Microphone Location Effects as a function of hearing aid type

	Frequency (Hz)								
	250	500	750	1000	1500	2000	3000	4000	6000
Body Aid	2	3	2	2	2	2	0	-1	-2
BTE	1	1	1	1	2	3	4	2	1
ITE	1	1	1	1	2	2	4	5	1
ITC	0	0	0	0	0	1	4	7	1
CIC	3	0	1	-1	2	4	6	8	2

Western
National Centre
for Audiology

Table 6.
DSL v5 Pediatric Targets for Soft Speech (55 dB SPL): Real Ear Aided Response (dB SPL re: ear canal)

	Frequency (Hz)								
Threshold dB HL	**250**	**500**	**750**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**
0	46	49	45	43	43	46	47	45	38
5	49	52	48	46	47	50	51	49	41
10	53	55	52	50	50	53	54	53	45
15	56	58	55	53	54	57	58	56	49
20	59	62	58	56	57	60	62	60	53
25	63	65	62	60	61	64	65	64	57
30	65	66	63	62	63	66	67	65	60
35	67	68	65	63	65	68	69	68	62
40	70	70	67	66	67	70	72	70	65
45	73	73	69	68	70	73	74	73	69
50	77	75	72	71	73	76	77	76	72
55	81	79	76	75	76	79	80	79	76
60	84	82	79	79	79	82	83	81	79
65	86	84	81	81	82	84	85	84	82
70	89	86	83	83	84	87	88	87	85
75	92	89	86	86	87	90	91	89	88
80	94	92	89	89	90	93	93	92	91
85	98	94	92	92	93	95	96	95	94
90	99	97	95	95	96	98	100	99	97
95	103	101	98	98	99	102	104	103	102
100	107	105	102	102	103	106	107	106	106
105	111	106	106	106	107	108	109	109	108
110	115	110	110	110	110	111	113	111	111

Western
National Centre
for Audiology

Table 7.
DSL v5 Pediatric Targets for Mid Speech (65 dB SPL): Real Ear Aided Response (dB SPL re: ear canal)

	Frequency (Hz)								
Threshold dB HL	**250**	**500**	**750**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**
0	56	59	55	53	53	56	57	55	48
5	59	62	58	56	56	59	60	58	51
10	61	64	61	59	59	62	64	62	54
15	64	67	64	62	62	66	67	65	58
20	67	70	67	65	66	69	70	68	61
25	70	73	69	68	69	72	73	71	65
30	71	74	71	69	70	73	75	73	67
35	73	75	72	71	72	75	76	75	69
40	76	77	74	72	74	77	78	77	72
45	78	79	76	75	76	79	81	79	75
50	81	81	78	77	79	82	83	82	78
55	85	85	82	81	81	84	86	85	81
60	89	88	85	84	85	88	90	89	85
65	93	91	88	87	89	92	94	93	89
70	97	95	92	91	93	96	98	97	94
75	101	99	96	95	97	100	101	99	98
80	104	102	99	99	100	103	103	102	101
85	108	104	102	102	103	105	106	105	104
90	109	107	105	105	106	108	110	109	107
95	113	111	108	108	109	112	114	113	112
100	117	115	112	112	113	116	117	116	116
105	121	116	116	116	117	118	119	119	118
110	125	120	120	120	120	121	123	121	121

Western
National Centre
for Audiology

Table 8.
DSL v5 Pediatric Targets for Loud Speech (75 dB SPL): Real Ear Aided Response (dB SPL re: ear canal)

	Frequency (Hz)								
Threshold dB HL	**250**	**500**	**750**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**
0	57	65	68	66	69	72	72	69	57
5	60	68	70	68	72	74	74	72	60
10	62	70	72	71	74	77	77	74	63
15	65	73	74	73	76	79	80	77	66
20	68	75	77	76	79	82	82	80	69
25	71	78	79	78	81	84	85	82	72
30	72	78	80	79	82	85	86	83	73
35	74	80	81	80	83	86	87	84	75
40	77	81	82	81	85	88	88	86	77
45	79	83	84	83	86	89	90	88	80
50	82	85	85	85	88	91	92	90	83
55	86	88	89	88	90	93	94	92	86
60	90	92	92	91	94	96	98	96	89
65	93	94	94	94	97	100	101	99	93
70	97	98	98	97	100	103	104	102	97
75	101	101	101	101	104	106	108	106	101
80	106	105	105	104	107	110	111	109	105
85	109	109	108	108	111	113	115	113	109
90	110	112	112	111	114	116	118	117	113
95	115	116	116	115	117	120	121	119	117
100	118	120	119	119	120	122	124	122	121
105	122	123	123	122	123	124	126	124	123
110	126	126	126	125	125	126	128	126	126

Western
National Centre
for Audiology

Table 9.
DSL v5 Pediatric Targets for Maximum Output (90 dB SPL narrowband): Real Ear Aided Response (dB SPL re: ear canal)

	Frequency (Hz)								
Threshold dB HL	**250**	**500**	**750**	**1000**	**1500**	**2000**	**3000**	**4000**	**6000**
0	90	90	90	90	90	90	90	90	90
5	90	91	91	91	92	92	92	92	91
10	91	92	93	93	93	94	94	93	93
15	92	94	94	94	95	95	96	95	94
20	93	95	95	96	96	97	98	96	95
25	94	97	97	98	98	99	100	98	97
30	95	98	98	99	99	100	101	100	98
35	96	99	99	100	101	102	103	101	100
40	98	100	100	102	102	104	104	103	101
45	100	102	102	103	104	105	106	104	103
50	102	103	103	105	105	107	108	106	105
55	104	105	105	107	107	109	110	108	107
60	106	107	108	109	109	111	112	110	109
65	109	109	110	111	111	113	114	112	111
70	111	112	112	113	114	115	117	115	113
75	114	114	114	115	116	118	119	117	116
80	117	117	117	118	118	120	121	119	118
85	120	119	119	120	121	122	124	122	121
90	124	122	122	123	123	125	126	124	124
95	127	125	125	125	125	127	129	127	126
100	131	127	127	128	128	129	131	129	129
105	135	130	130	130	131	132	134	132	132
110	139	133	133	133	133	134	136	135	135

Appendix 1: How does DSL v5 by Hand differ from Software Implementations?

Here is a list of features that are not yet implemented on DSL v5 by hand, along with a summary of their effects on targets:

1. **Adult vs. Child Targets**
   Adult targets in DSL 5 are approximately 7 dB lower than pediatric targets for a moderate hearing loss. Adult targets are meant to be used with patients who have acquired hearing losses post-lingually. We will add adult target tables to a future version of DSL 5 by hand.
2. **Quiet vs. Noise Targets**
   Noise targets in DSL 5 are slightly lower than quiet targets and use a higher compression threshold. Noise targets are meant to provide listening comfort in louder situations, but are not expected to improve speech recognition in noise. We will add adult target tables to a future version of DSL 5 by hand.
3. **Targets for Conductive And/or Mixed Hearing Losses**
   DSL v5 software implementations add 25 % of the air bone gap to the output limiting targets, and a lesser amount for speech targets. This is not currently represented in DSL 5 by hand.
4. **Targets for binaural fittings**
5. DSL v5 software implementations subtract 3 dB from speech targets for adult hearing aid fittings if the fitting is binaural. This is not currently represented in DSL 5 by hand.
6. **Smoothing of targets across frequency**
   DSL v5 software implementations provide a slight smoothing of the target frequency response across frequencies. This will cause software-generated targets to differ slightly from those shown in DSL v5 by Hand for non-flat hearing losses.
7. **Venting corrections**
   DSL v5 software implementations incorporate venting corrections in the transformation of targets to the coupler. The corrections take into account both incoming sound through the vent and sound exiting the ear canal through the vent. This is not currently represented in DSL 5 by hand.
8. **Adjustments to compression targets** for varying numbers of channels and for varying compression thresholds
   DSL v5 software implementations allow adjustments to the target for details of the compression characteristics of the hearing aids. This will cause software-generated targets to differ slightly from those shown in DSL v5 by Hand in some cases.

Bagatto, M, Moodie, S, Scollie, S, Seewald, R, Moodie, K, Pumford, J, Liu, KPR (2005). Clinical protocols for hearing instrument fitting in the Desired Sensation Level method. Trends in Amplification, 9(4): 199-226.

Scollie, S. (2007). DSL version v5.0: Description and Early Results in Children, AudiologyOnline, 1/15/2007. from http://www.audiologyonline.com/articles/article_detail.asp?article_id=1753.

Scollie, S. & Bagatto, M. (2010). Fitting Hearing Aids to Babies: Three Things You Should Know. 2010 Update. www.AudiologyOnline.com/ceus/preview_text_course.asp?class_id=17201, posted 10/9/2010.

Scollie, S, Seewald, RC, Cornelisse, L, Moodie S, Bagatto, M., Laurnagaray, D, Beaulac, S. & Pumford, J (2005). The Desired Sensation Level Multistage Input/Output Algorithm. Trends in Amplification, 9(4): 159-197.