Table S1. Subject demographics and baseline characteristics

Category	Features	SLE patients (n = 31)	Healthy subjects (n = 21)
Demographic	Age, year (mean ± SD)	33.52 ± 13.79	25.12 ± 1.81
	Gender, male, n (%)	3/31 (9.68%)	4/21 (19.05%)
	Female, n (%)	28/31 (90.32%)	17/21 (80.95%)
	Race, n (%)		
	Asian	31/31 (100%)	21/21 (100%)
	African American	0 (0%)	0 (0%)
	Unknown/Other	0 (0%)	0 (0%)
Laboratory parameters	SLEDAI-2K (mean ± SD)	5.93 ± 3.98	ND
	Anti-dsDNA positive No (%)	21/31 (67.74%)	ND
	C3 levels, mg/L (#)	905 (625-1300)	ND
	C4 levels, mg/L (#)	150 (50-360)	ND
	ESR, mm/h (#)	60 (22.5-72.5)	ND
Clinical manifestations	Nephritis, n (%)	12/31 (38.71%)	ND
	Vasculitis, n (%)	3/31 (9.68%)	ND
	Malar rash, n (%)	2/31 (6.45%)	ND
	Discoid rash, n (%)	1/31 (3.22%)	ND
	Purtscher retinopathy, n (%)	2/31 (6.45%)	ND
	Organic brain syndrome, n (%)	2/31 (6.45%)	ND
	Low complement level n, (%)	9/31 (29.03%)	ND
	Increased DNA binding n, (%)	10/31 (32.26%)	ND
Treatment	Prednisolone, n (%)	28/31 (90.32%)	ND
	Antimalarial, n (%)	25/31 (80.64%)	ND
	Cyclophosphamide, n (%)	16/31 (51.61%)	ND
	Azathioprine, n (%)	6/31 (19.35%)	ND
	Mycophenolate, n (%)	14/31 (45.16%)	ND
	Triamcinolone, n (%)	4/31 (12.90%)	ND
	Methotrexate, n (%)	2/31 (6.45%)	ND

ND**:** Not done; SLEDAI-2K: Systemic Lupus Erythematosus Disease Activity Index 2000; Anti-dsDNA: Anti-double strand DNA; C3: Complement 3; C4: Complement 4; ESR: Erythrocyte Sedimentation Rate. # = Median **(**Interquartile range**)**

Table S2. Flow cytometry panel used for this study

	Marker	Fluorochrome	Clone	Catalog Number	Company
1	CD19	FITC	HIB19	302206	BioLegend
2	CD20	APC/Cy7	2H7	302313	Biolegend
3	CD21	APC	Bu32	354906	BioLegend
4	CD27	PE	M-T271	356406	BioLegend
5	CD27	APC/fire	M-T271	356428	BioLegend
6	CD38	AF700	HB-7	356624	BioLegend
7	IgD	PE/Dazzle	IA6-2	348240	BioLegend
8	IgD	PE/Cy7	IA6-2	348210	BioLegend
9	IgG	PerCP cy5.5	M1310G05	410710	BioLegend
10	CD11c	AF700	Bu15	337220	BioLegend
11	CD86	PE/Cy5	IT2.2	305408	BioLegend
12	CD40	PE/Cy5	5C3	334314	BioLegend
13	HLA-DR	APC	G-46-6	559866	BD Pharmingen
14	IL-21R	PE/Cy7	17A12	359514	BioLegend
15	FcRL4	PE	413D12	340204	BioLegend
16	FcRL5	PE	509f6	340304	BioLegend
17	CXCR5	AF700	J252D4	356916	BioLegend
18	CCR7	PE	G043H7	353204	BioLegend
19	pSyK (Y352)	PE/Cy7	17A/P-ZAP70	561458	BD Bioscience
20	pBLNK (Y84)	AF647	J117-1278	558443	BD Bioscience
21	pPLCγ2 (Y759)	PE	K-86-689.37	558490	BD Bioscience
22	Zombie Red™ Fixable Viability Kit	-	-	423109	BioLegend

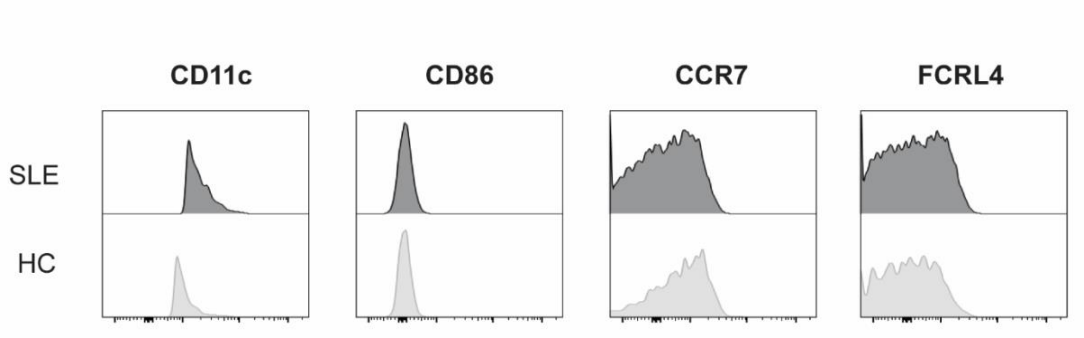

Figure S1. The aNAV B cells of SLE patients exhibited T cell costimulatory phenotype
Representative histograms of CD11c, CD86, CCR7 and FCRL4 expression on aNAV B cells of SLE patients (shaded black area) and HCs (shaded grey area).

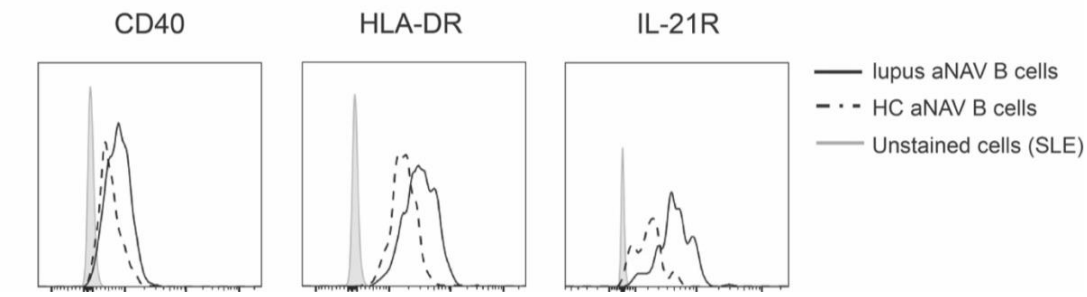

Figure S2. The *ex vivo* flow cytometric analysis of CD40, HLA-DR and IL-21R expression on aNAV B cells

Representative histogram overlays denoted an expression of CD40, HLA-DR and IL-21 on aNAV B cells from SLE (black solid line) and HC (black dash line) compared with unstained control (shaded plot).

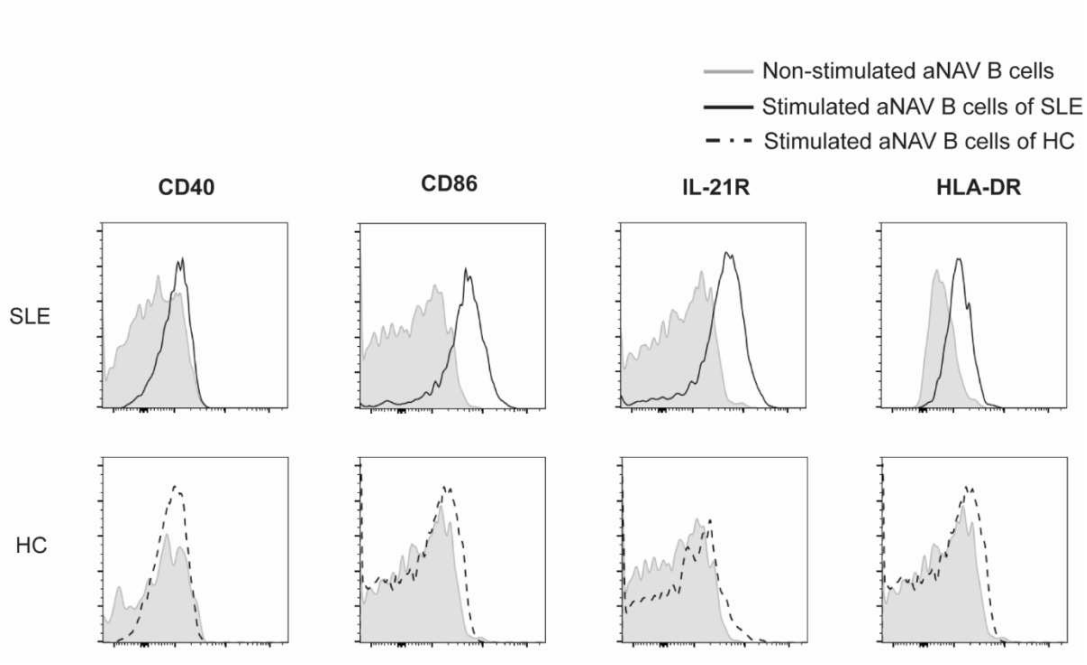

Figure S3. The lupus aNAV B cells had upregulated T cell costimulatory molecules after receiving BCR and TLR7/8 signaling *in vitro* cultures

Representative histogram overlays for CD40, CD86, IL-21R and HLA-DR expression on aNAV B cells from SLE patients (black solid line) and HC (black dash line) after stimulation with R848, IL-2 and autoantigen compared to non-stimulated aNAV B cells (shaded grey area).